The Canadian Entomologist

Vol. LXXXVIII Ottawa, Canada, September 1956 No. 9

Old World Lonchaeids of the Genus *Silba* Macquart (= *Carpolonchaea* Bezzi), with Descriptions of Six New Species (Diptera: Lonchaeidae)[1]

By J. F. McAlpine[2]

Many species of the genus *Silba* Macquart (= *Carpolonchaea* Bezzi) are important pests of fruits and vegetables during their larval stages but taxonomically the adults are poorly known. Representatives of 15 species of the genus from widely separated localities in the Old World have come to hand during studies on the family. This paper clarifies the identities of the males of these 15 species, six being described as new to science.

All species treated belong to the "carpophilous series" of the family. Bezzi (1920) erected the name *Carpolonchaea* (type: *Lonchaea plumosissima* Bezzi) to contain this largely tropical and subtropical group as a subgenus of *Lonchaea* Fallén. *Carpolonchaea* was subsequently raised to full generic status by Enderlein (1936). Unfortunately, the name must sink in favour of *Silba* Macquart (1851) (monobasic for *S. virescens* Macq.). Collin (1953), who examined the damaged type, established the family status of *S. virescens* and added that it has two strong sternopleural bristles and a haired prosternum; both these characters are diagnostic of *Carpolonchaea*. This information, plus Macquart's (1850) illustration of the head of *virescens*, showing that the type originally bore a plumose arista, removes all doubt that *Silba* is a senior synonym of *Carpolonchaea*.

The most reliable criteria for distinguishing *Silba* species are in the male genitalia; indeed, it is almost impossible to identify some species without studying these structures.

The drawings of the male genitalia were made under a compound microscope by means of a camera lucida.

The following explanations aid in interpreting the terminology used. The locations of the various thoracic setae and hairs are shown in Figs. 2 and 3. The frons and lunule, with their associated bristles and setulae, are shown in Fig. 1; the length of the frons referred to here is the distance between the uppermost margin of the lunule and the lower margin of the foremost ocellus; the width is the minimum distance between the inner margins of the compound eyes. Antennal measurements are of the maximum length and width of the inner (mesal) aspect of the third antennal segment.

The numbers in parentheses after the approximate length-width ratio are measurements in the same scale made by means of a squared ocular grid in a Bausch and Lomb dissecting microscope with a 15X ocular and a 7.5X objective. The factor to convert these figures to millimeters is .13.

No key to species is offered at this time because I have not seen representatives of many of the species of this genus. Each new species described below is referred to the couplet into which it falls in one or other of Bezzi's (1920) keys. With these keys and the additional information and figures provided here, little difficulty should be experienced in identifying the 15 species treated.

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Genus *Silba* Macquart

Silba Macq., 1850, Dipt. exot.,[3] supp. 4: 304 (Roret, Paris);

[3]According to Horn and Schenkling (1928, Index Literature Entomologicae, p. 779), Supplement 4 of "Diptéres Exotiques Nouveaux on Peu Connus" was published as a reprint before appearing in a journal, and then in two sections in a journal as follows:—

1. Reprint, 364 pp., 28 pls. Roret, Paris. 1850;
2a. Mem. Soc. Roy. Sci. Agr. Arts, Lille, 1849, pp. 309-479, pls. 1-14. 1850;
2b. Mem. Soc. Roy. Sci. Agr. Arts, Lille, 1850, pp. 134-294, pls. 15-28. 1851.
1851, Dipt exot., p. 277 (Memoires).

Type of genus *Silba virescens* Macquart. (By monotypy).

Carpolonchaea Bezzi, 1920, Bull. Ent. Res. 11: 99. (As a subgenus of Lonchaea Fallen).

Type of genus: *Lonchaea plumosissima* Bezzi. (By original designation).

Diagnostic Characters.—The following combination of characters separates the genus *Silba* Macq. from the other lonchaeid genera: third antennal segment elongate, arista plumose, lunule setulose, post-stigmatal bristles or hairs absent, sternopleuron with two bristles, prosternum with hairs (except in *pendula* Bezzi).

Silba abstata new species

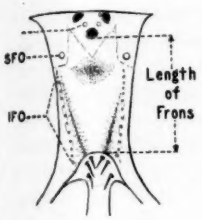
Figs. 4-7

A medium-sized species, about as large as *S. aristella* (Beck.) and *S. adipata* n.sp., with black tarsi and white calyptrae. The male frons relatively narrower than in most species, and broadened both above and below the mid-section. One of the oral setulae vibrissa-like. The body colour the usual greasy blue-black, but the wing distinctly yellowish-brown fumose anteriorly and at the base in mature specimens. The female ovipositor wider than in any known species of the genus with the possible exception of *S. admirabilis* n.sp.

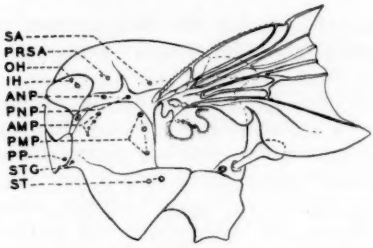
Male.—Head about five-sevenths as high as wide. Frons relatively narrower than usual in the family; at the narrowest point about one-sixth head width (13.0: 2.2) and about three-fifths as wide as high (2.2: 3.75); somewhat hour-glass-shaped, the narrowest point being slightly below the middle; dull black in colour but not appearing pollinose in most lights; from 16 to 18 inferior orbital setulae present on each side; genovertical plates bare and polished blue-black above the orbital bristle; in side view, no setulae visible immediately above the orbital bristles. Immediately below the ocellar plate a rather distinctive, longitudinal, dimple-like depression. Parafacials linear. One of the oral setulae strongly vibrissa-like, i.e., longer and stronger than the others in the series, with three or four smaller setulae above it in a uniserial row. Lunule silvery pollinose with 12 relatively strong setulae. Second antennal segment entirely reddish-brown, and the third narrowly reddish-brown at the base, inside; third antennal segment about 2⅕ times as long as wide. Plumosity of arista about as wide as the width of the third antennal segment, strongly tapered from slightly beyond

Figs. 1-12. *Silba* spp. 1, Anterior aspect of frons and lunule of *chalkei* (paratype); 2, lateral, and 3, dorsal aspect of thorax showing principal setae (semi-diagrammatic); 4, ventral, and 5, right lateral aspect of male genitalia of *abstata* (holotype); 6, dorsal aspect of ovipositor, and 7, of apex of scutellum (same scale) of *abstata* female (allotype); 8, 9, ventral, and 10, right lateral aspect of male genitalia of *adipata* (holotype); 11, ventral, and 12, right lateral aspect of male genitalia of *aristella* (Ruo River, Chiromo, Nyasaland).

AC, acrostical bristle; ALS, anterior lateral scutellar bristle; AMP, anterodorsal mesopleural bristle; ANP, anterior notopleural bristle; AS, apical scutellar setula; DC, dorsocentral bristle; IFO, inferior orbital setula; IH, inner humeral bristle; IS, lateral scutellar setula; OC, ocellar bristle; OH, outer humeral bristle; PAL, postalar bristle; PI, postintra-alar bristle (= intra-alar bristle); PLS, posterior lateral scutellar bristle; PMP, posterior mesopleural bristle; PNP, posterior notopleural bristle; PRSA, presupra-alar bristle; PSA, postsupra-alar bristle; SA, supra-alar bristle; SFO, superior oribtal bristle (= orbital bristle); ST, sternopleural bristle; STG, stigmatal bristle (=epimeral bristle).



1. chalkei



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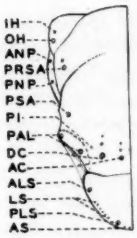

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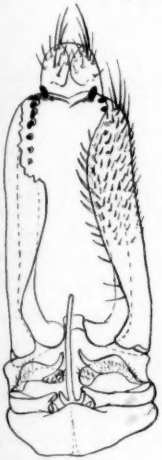
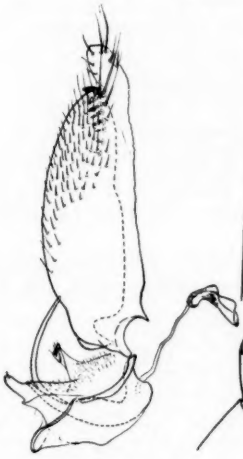
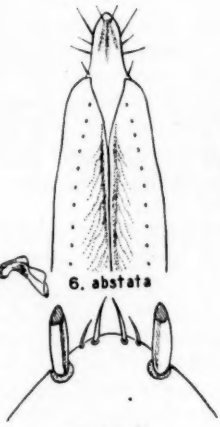


4. abstata

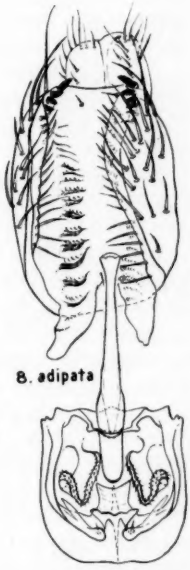


5. abstata



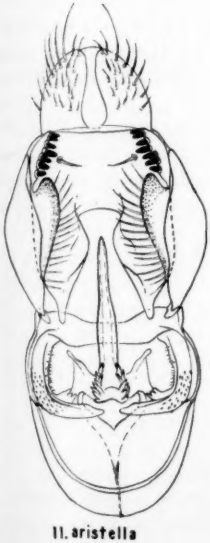
6. abstata

7. abstata

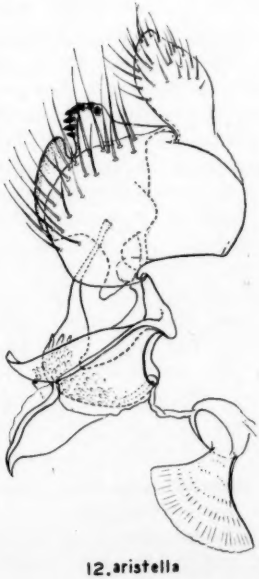


8. adipata

9. adipata



11. aristella



12. aristella

10. adipata

the middle to the apex, and bearing the usual number of plumules (about 17) above and below. Each palpus with a rather strong, outwardly directed bristle at the apex.

Mesonotum mostly shining blue-black, but entirely cinereous pollinose posteriorly from the area immediately in front of the mesonotal macrochaetae; this pollen continuing posteriorly over the entire scutellum. Scutellum with four or five lateral setulae on each side, and a pair of apical setulae between the apical bristles. Mesopleuron anteriorly with two strong anterodorsal bristles, with a weak one both above and below them, and posteriorly with three strong posterior mesopleural bristles. Sternopleuron with two bristles, the anterior one weaker; no setulae present behind the strong sternopleural bristles. Mesopleuron and sternopleuron uniformly, lightly pollinose. Prosternum with five or six fine hairs on each side anteriorly.

Legs and tarsi black; mid and hind tibiae each with a distinct preapical dorsal bristle, the one on the midtibia at least as long as the width of the tibia. Midtibia with a relatively very strong ventral bristle at the apex, i.e., as long as the greatest diameter of the midfemur. Wings distinctly yellowish-brown fumose anteriorly and at the bases in mature specimens, but this character less distinct in teneral, reared specimens. Calyptrae and their fringes white to pale yellowish-white.

Disc of the abdomen entirely lightly cinereous pollinose from an anterior view, but subshining blue-black from other angles, the most heavily pollinose area being the disc of the second tergum.

Male genitalia as shown in Figs. 4 and 5.

Female.—Agreeing with the male except for the following sexual differences: Frons relatively narrow, distinctly less than one-fourth as wide as head (2.5: 11.0) at the narrowest point; about 1⅔ as long as wide (3.4: 2.5); anteriorly with two distinct, converging grooves in the allotype, but these probably less pronounced in fully matured specimens. The ovipositor (Fig. 6) very distinctive, being relatively very broad for this genus, at its widest point distinctly wider than the distance between the apical scutellar bristles (1.45: 1.3) (Fig. 7).

Holotype, ♂, and *allotype*, ♀.—Roy. Botanic. Gdns., Paradeniya, Ceylon, Aug., 1903, E. E. Green, 1903-241, bred from rotting stumps of young shoots of *Dendrocalamus giganteus;* in the British Museum (Natural History).

Paratype.—♂, Ammati, S. Coorg., India, 3100′, Oct., 1952, P. S. Nathan, type number 6272 in the Canadian National Collection.

In Bezzi's (1920) key to the Indo-Australian species, *abstata* runs to *bisulcata* Bezzi but differs from that species as follows: Male frons not nearly twice as long as wide; wings not "deep yellow" and ovipositor abnormally wide as against a normal narrow one in *bisulcata*. *Abstata* may easily be confused with *calva* Bezzi; in the former however, the plumosity of the arista is distinctly longer and the frons narrower; *abstata* has two, only, strong anterodorsal mesopleurals with a weak one below and several setulae above them, whereas *calva* has three anterodorsal bristles with one weak setula above them and one below. In *abstata* there are, at most, five lateral scutellar setulae, whereas in *calva* there are about seven longer and stronger ones. In each species the male genitalia and the female ovipositors are very different (Figs. 4-7, 54-55); the ovipositor of *calva* is narrow as usual in this genus.

Silba adipata new species
Figs. 8-10

A medium-sized species, somewhat smaller than *S. plumosissima* (Bezzi). The base of the antennae, the lunule, and usually the adjoining areas of the

frons brownish or brownish-orange. Thorax, including the scutellum, and the abdomen appearing greasy-shiny; notum relatively densely whitish pollinose, with distinct aeneous-green reflections in mature specimens. Scutellum often rather strikingly greenish as in *Lonchaea scutellaris* Rond. Wings clear; veins pale yellow. Calyptrae and their fringes white to very pale yellow. Tarsi entirely dark brown to almost black.

Male.—Head about one-fifth wider than high. Frons fully one-fourth as wide as head (2.8: 11.66); about four-fifths as wide as high (2.8: 3.5); very little narrowed anteriorly; with a rather conspicuous, but poorly defined, transverse depression immediately in front of the anterior ocellus; distinctly silky-shiny but also uniformly, lightly dusted with whitish pollen which iridesces under some lights; each side with from 12 to 19 inferior orbital setulae; no hairs visible above the orbital bristle in side view. Parafacials almost linear, silvery pollinose. Oral setulae uniserial, without an outstanding vibrissa-like bristle among them. Lunule densely silvery pollinose over an orange-brown ground colour, bearing 10 setulae of about the same length and strength as the interfrontal setulae. Third antennal segment about 2⅝ as long as wide (3.5: 1.3), always extensively orange to orange-brown at the base, inside. Plumosity of arista slightly wider than the width of the third antennal segment; basal one-third of the arista orange-yellow.

Mesonotum uniformly, rather heavily dusted with whitish pollen; greasy-shiny; bronzy-green to aeneous-blue in colour. The usual bristles, including two dorsocentrals, strong, whereas the setulae are short and depressed. Scutellum rather contrastingly shining bronzy-green in most specimens; always heavily pollinose; with four or five lateral setulae on each side between the lateral and the apical scutellar bristles and with a weaker pair between the pair of apical bristles. Pleurae entirely pollinose; concolourous with mesonotum. One stigmatal, three strong and one weak anterodorsal mesopleurals, and three posterior mesopleural bristles present; sternopleuron often with a weak setula behind the posterior sternopleural bristle. Prosternum with three or four weak hairs on each side anteriorly.

Legs and tarsi brownish-black; preapical dorsal bristles of the mid and hind tibiae hardly distinguishable from the hairs, those of the front tibiae indistinguishable.

Wings pale hyaline; veins pale yellowish. Calyptrae white or pale yellow with concolourous fringes.

Abdomen, like the mesonotum, entirely rather densely pollinose and with the same greasy, aeneous colour. Genitalia (Figs. 8-10) similar to those of *S. filifera* (Bezzi), but aedeagus much shorter; in addition the surstyli much more distinctly ridged anteriorly and bearing a lesser number of stout teeth posteriorly.

Female.—Frons wider than high (3.66: 3.0), about one-third head width (3.66: 11.0); transverse depression in front of the orbital bristles and the anterior ocellus more clearly defined than in the male, forming an inverted W; with thirteen inferior orbital setulae in the allotype. The aristal plumosity narrower than in the male, i.e., slightly narrower than the third antennal segment. The lowermost two or three oral setulae stronger than the others.

The apical one-third of the ovipositor tapering evenly to a sharp point; the apical segment with several very short hairs on each side, the longest being hardly as long as the width of the ovipositor opposite the base of the hair.

Holotype, ♂, and *allotype*, ♀.—Lazio, Terracina, Italy, 7.50, Sacca.

Paratypes.—♂, Lazio, Circio, Italy, 7.40, Sacca; ♂, Roma, Italy, 5.38, G. Sacca; ♂, Cyprus, Nicosin, 7.VI.37, Th. Shiakides, bred from fallen figs, det.

Lonchaea (*Carpolonchaea*) *aristella* Beck. (by) van Emden 1939; ♂, Egypt, Min. Agri. (Egypt), Coll. Baghib, Giza, on figs, 20.7.30; ♀, Khartoum, 26.1.1915, no. 8529, bred from fruits of "bedingan", presented by Imp. Bur. Ent. to Brit. Museum 1924-291, det. *Lonchaea gibbosa* de Meij. (by) G. A. K. Marshall; ♀, with same data as preceding except no. is 8519 and it bears no det. label.

The holotype, allotype, and one paratype are in Dr. Sacca's collection; three paratypes are in the British Museum (Natural History) and two are in the Canadian National Collection at Ottawa, type number 6273.

This species runs to *S. pollinosa* (Kert.) in Bezzi's (1920) key to the Indo-Australian species and to *S. laevis* (Bezzi) in his key (1920) to the Ethiopian species. I have not seen specimens of the former species but from Kertesz's (1901) description of *pollinosa*, *adipata* differs as follows: aristal plumosity wider than third antennal segment (arista very short-haired in *pollinosa*); frons of male one-fourth head width (one fifth in *pollinosa*); frons of female with an irregular depression in the form of an inverted W (without distinct grooves in *pollinosa*); scutellum with four or five lateral setulae on each side and a pair of apical setulae in addition to the four scutellar bristles (with four scutellar bristles, only, in *pollinosa*). *Adipata* is a much more pollinose species than *laevis*, especially on the mesonotum; furthermore, *laevis* differs in possessing entirely black antennae and a more broadly plumose arista.

S. aristella (Beck.), the only other member of this genus reported from Europe, is superficially very similar to *adipata; aristella*, however, possesses rather strong preapical dorsal bristles on the mid and hind tibiae, and has two, only, anterodorsal mesopleural bristles.

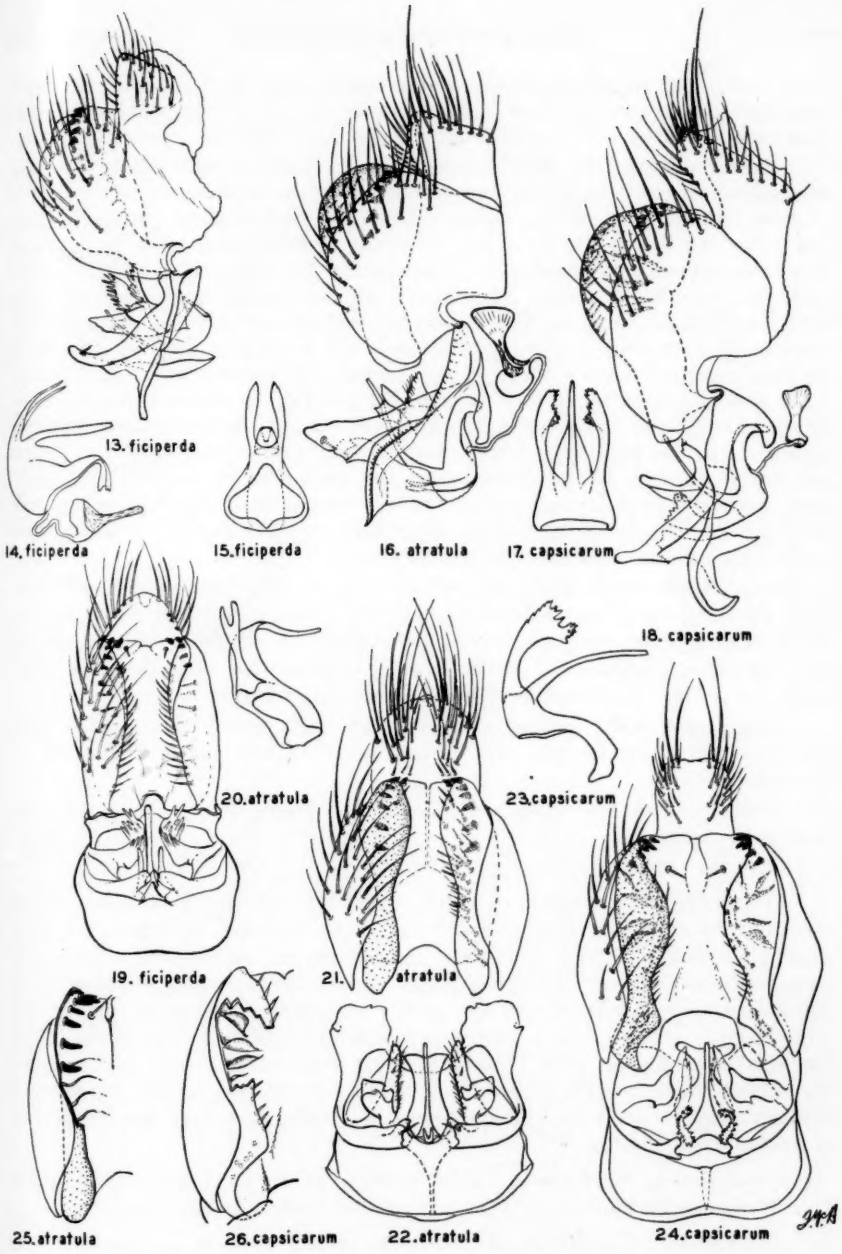
The male genitalia of *adipata* and *aristella* (Figs. 8-12) are very different.

***Silba admirabilis* new species**

Figs. 29-31

A moderately large species, comparable in size to *S. plumosissima* (Bezzi) and *S. ophyroides* (Bezzi). All the metatarsi yellowish as in *S. chalkei* n.sp. and *S. pallicarpa* (Bezzi). The third antennal segment unusually long and narrow, and the arista rather short-plumose. No distinctly vibrissa-like bristle among the oral setulae. Mesopleuron with four anterodorsal mesopleural bristles, the lowermost almost hair-like, and three strong posterior mesopleural bristles, the uppermost curved ventrad over the others. The wings pale, milky-hyaline with pale yellowish veins. The calyptrae rather larger in size than usual, entirely white in colour.

Male.—Frons approximately one-third longer than wide (4.0: 3.0) and almost one-fourth as wide as the head (3.0: 13.0); without distinct grooves or depressions; entirely silky-shiny, but appearing very lightly cinereous pollinose anteriorly under oblique lights. Hairs of the front rather coarse, the four immediately above the lunule at least as strong as the strongest oral setula. Inferior orbital setulae, 14 in number, about as long as the distance between the anterior and posterior ocelli. Genovertical plate polished blue-black; entirely bare in the holotype, but in side view with one to several fine interfrontal hairs evident above the orbital bristle. Parafacials, genae, face and lunule silvery-grey pollinose. The distance between the lower corner of the eye and the mouth margin distinctly greater than the maximum width of a palpus. Oral margin with about six oral setulae, the lowermost being the strongest but not outstandingly so. Lunule dark in ground colour with six setulae visible on each side. Third antennal segment unusually long and narrow, i.e., about four times as long as wide



Figs. 13-26. Male genitalia of *Silba* spp. 13-15 and 19, *ficiperda* (Los Banos, Phil. Is.): 13, lateral, and 19, ventral aspect; 14, right lateral, and 15, anteroventral aspect of aedeagus. 16, 20-22, and 25, *atratula* (Cameron's Highlands, Malaya): 16, right lateral, 21, and 22, ventral aspect, 20, oblique anterolateral aspect of aedeagus, 25, ventral aspect of external genitalia with part of the left surstylus cut away to show the teeth and folds on its inside surface. 17, 18, 23, 24, and 26, *capsicarum* (holotype): 18, right lateral, and 24, ventral aspect, 17, anteroventral, and 23, right lateral aspect of aedeagus, 26, ventral aspect of external genitalia with part of the left surstylus cut away to show the folds on its inner surface.

(5.0: 1.25), and slightly narrower in the middle than at either end; narrowly brownish-orange at the base inside. Arista brownish-yellow at the base; plumosity about as wide as the width of the third antennal segment.

Thorax shining, blue-black, especially on the notum; very lightly pollinose throughout; behind the strong dorsal bristles of the mesonotum the pollen is evident only in very oblique lights. Pollen of the scutellum plainly evident, uniformly distributed and iridescent. Bristling of the notum moderately strong; three dorsocentrals distinguishable; intra-alar bristle about equal in size to the posterior notopleural bristle. Scutellum with four lateral setulae on each side between the usual strong scutellar bristles but without apical setulae. Mesopleuron, anteriorly, with four anterodorsal bristles, the lowermost two of the series weaker; posteriorly, with five posterior bristles, the uppermost directed downward almost at right angles to the others, the two lowermost weak and hair-like. Sternopleuron with two bristles, the anterior one but slightly weaker than the posterior one; no hairs behind the strong sternopleural bristles. All the pleural sclerites uniformly silky pollinose with the exception of a small, triangular, bare spot on the depressed portion of the mesopleuron slightly behind the stigmatal bristle. Prosternum with seven hairs on each half in a double row around the anterior and anterolateral margins.

Femora and tibiae black; anteroventral series of setulae of the midfemur with the distal three bristles stronger than the others. Preapical dorsal bristles of all tibiae evident, but rather weak, particularly on the front tibiae; those of the midtibiae strongest. All metatarsi orange-brown, the front metatarsi more evidently so, the apical two or three segments progressively darker.

Wings pale, milky-hyaline with yellowish veins, much as in *chalkei* n.sp. Calyptrae, including margins and fringes, white; rather larger than usual in the group.

Abdomen dark blue-black with a satin-like sheen, more heavily pollinose on the disc anteriorly.

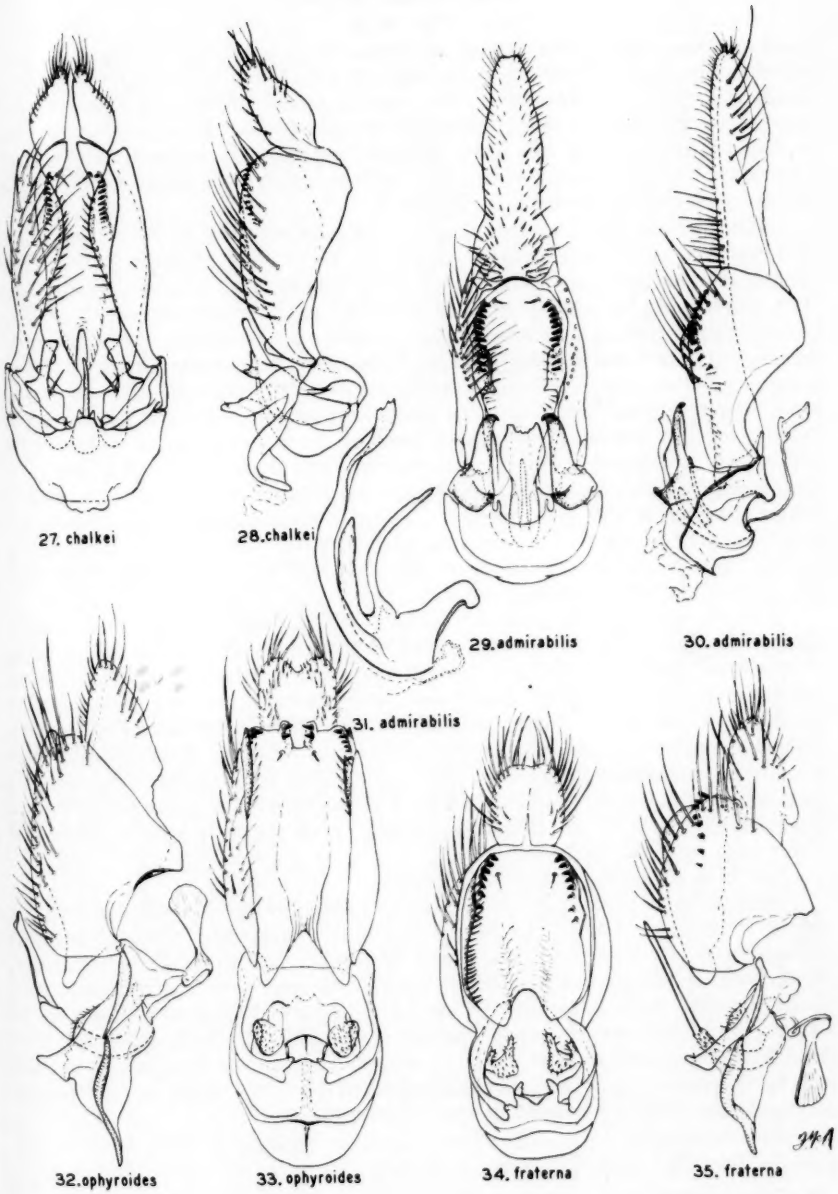
Genitalia (Figs. 29-31).

Female.—In most respects as in the male, but differing as follows: Frons three-fourths as long as wide (3.0:4.0) and about one-third as wide as the head (4.0:12.0); with a distinct, transverse, crescent-shaped depression on each side immediately in front of, and slightly mesad of, the orbital bristles; mesad of these depressions with a pair of shallow, poorly delimited, longitudinal depressions lying roughly parallel to each other but converging slightly at the lunule. The lunule of the allotype with 17 setulae. The frons with several setulae above the orbital bristle, visible in side view. One of the oral setulae longer and stronger than the others in this specimen. The ovipositor very similar to that of *abstata* n.sp. (Fig. 6).

Holotype.— ♂, Kodaikanal, Pulney Hills, 6500′, S. India, IV (April) 1953, P. S. Nathan; type number 6274 in the Canadian National Collection.

Allotype.— ♀, Coimbatore, S. India, IX (Sept.) 1953, P. S. Nathan; type number 6274 in the Canadian National Collection.

This species runs to *pallicarpa* Bezzi (1920) in his key to the Indo-Australian species but it differs from that species in having several lateral scutellar setulae in addition to the usual four bristles. From *chalkei* n.sp. it can be distinguished by its larger size and the absence of apical scutellar setulae between the usual apical scutellar bristles. The genitalia (Figs. 29-31) are very distinctive.



Figs. 27-35. Male genitalia of *Silba* spp. 27 and 28, *chalkei* (holotype): 27, ventral, and 28, right lateral aspect; 29-31, *admirabilis* (holotype): 29, ventral, and 30, right lateral aspect; 31, right lateral aspect of aedeagus (greatly enlarged); 32, and 33, *ophyroides* (Dwoli, Ugandi): 32, right lateral, and 33, ventral aspect (aedeagus not shown); 34, and 35, *fraterna*, (holotype): 34, ventral (aedeagus not shown), and 35, right lateral aspect.

Silba aristella (Becker)

Figs. 11, 12

Lonchaea aristella Becker, 1902, Mittheil. Zool. Mus. Berlin, p. 29 (type: ♂, Egypt).
Carpolonchaea aristella (Becker), Hennig, 1938, Acta Zool. Lill. 6: 363-4, 390 (Formosa).

I have accepted Hennig's (1948) determination of *aristella* (Becker) and have purposely omitted other references to this species. It is possible, or even probable, that some of the early records apply to *S. adipata* new species. Characters for separating the two are discussed under the latter species. The following characters are noted for *S. aristella*:

Male.—Frons slightly more than 1¼ as long as wide (3.0:2.3) and about two-ninths as wide as the head (2.3:10.5); silky shiny through a very thin coating of cinereous pollen, this pollen being visible under a very slanting light; with three series of setulae on each side, i.e., a complete row of 12 regular, dorsomedianly directed inferior orbital setulae, an irregular row of ventromedianly directed setulae, and, between these two rows, another sparsely placed, irregular row of ventromedianly directed setulae; the setulae of the two median rows longest immediately above the lunule; no setulae above the orbital bristle in side view; no distinct depression in front of the anterior ocellus. One of the oral setulae developed stronger than the rest, i.e., distinctly vibrissa-like, with three smaller setulae both above and below it. Lunule orange-brown in ground colour; bearing at least eight setulae. Third antennal segment rather strikingly long and narrow, about 3½ times as long as wide (3.5:1.0); the base, inside, broadly orange-brown. Arista short plumose; width of plumosity about one-half that of the third antennal segment.

Thorax, pleurae, and abdomen shining black with faint greenish and/or bluish reflections, these colours being visible through a uniform, but thin, coating of cinereous pollen. Scutellum dull brassy-green, relatively heavily pollinose; bearing several lateral setulae on each side between the lateral and apical scutellar bristles, and with two weaker ones between the apical scutellars. Mesopleuron with three posterior and two, only, anterodorsal bristles. Sternopleuron bare behind the sternopleural bristles. Prosternum with four or five fine hairs on each anterolateral margin. Mid and hind tibiae each with a distinct preapical dorsal bristle, those of the midtibiae stronger, each about as long as the width of the tibia opposite the bristle.

Genitalia as shown in Figs. 11 and 12.

Aristella keys to couplet 22 in Bezzi's (1920) key to Ethiopian species. It differs from *laevis* (Bezzi) in having the lunule and third antennal segment orange-brown at the base, inside (black in *laevis*), narrower aristal plumosity, (wider than third antennal segment in *laevis*), and two, only, anterodorsal mesopleural bristles (three in *laevis*). It can be distinguished from *ophyroides* by its smaller size, duller colour, and longer antennae. *Silba nigritella* (Mall.) (1930) from Samoa is at least closely related to *aristella* and may be conspecific, but this can be determined only by an examination of the type series of the former species in the British Museum (Natural History).

Material examined.— ♂, Ruo River, Chiromo, Nyasaland, 1916, R. C. Wood, pres. by Imp. Bur. Ent. Brit. Mus., 1924-291.

Silba atratula (Walker)

Figs. 16, 20-22

Lonchaea atratula Walker, 1860, Proc. Linn. Soc. Zool. 4: 146 (type: Macassar, Celebes); 1866, Jour. Linn. Soc. (Zool.) 9 (33): 24; Kertesz, 1901, Term. Füzet. 24: 84.
Lonchaea (*Carpolonchaea*) *atratula* Walker, Bezzi, 1920, Bull. Ent. Res. 11: 205, 207 (Butuan, Mindanoa, Singapore).

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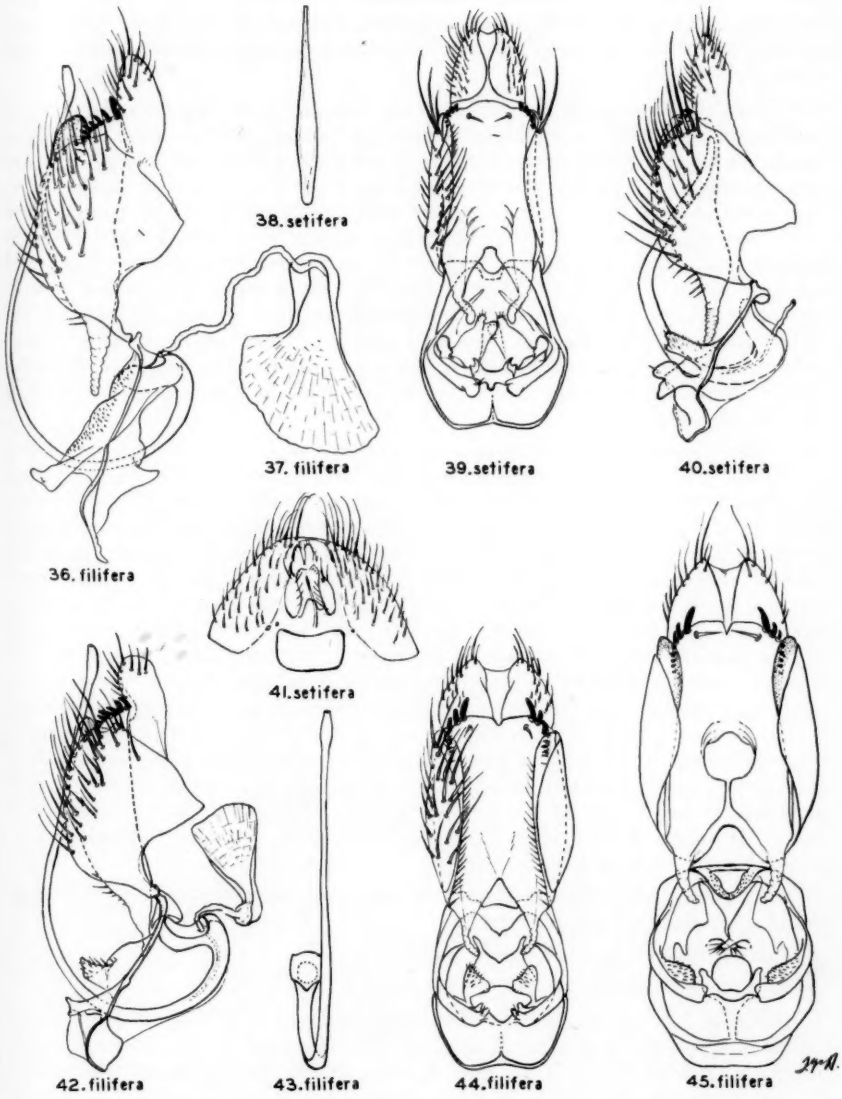


Figs. 36-45. *Silba* spp. 36, 37, and 45, male genitalia of *filifera* (Nuku'alofa, Tonga Is.): 36, right lateral view; 37, right lateral view of ejaculatory bulb with apodeme, and seminal duct attached, 45, ventral view (aedeagus not shown); 42-44, male genitalia of *filifera* (Kuala Lumpur, Malaya): 42, right lateral, and 44, ventral aspect (aedeagus not shown), 43, ventral aspect of aedeagus; 38-41, *setifera* (Taiping, Malaya): 38, ventral aspect of apical half of aedeagus, 39, ventral aspect of male genitalia (aedeagus not shown), 40, right lateral aspect of male genitalia, 41, ventral aspect of the apex of male abdomen, showing setaceous hairs.

A moderately large species, comparable in size to *S. plumosissima* (Bezzi) and *S. capsicarum* new species. Brownish-black in colour with entirely black antennae and legs, and dark brown calyptrae; the wings, as well, dark brownish fumose. Identified at once by the dull, velvety-brown, pollinose disc of the (male) abdomen.

Male.—Frons entirely dull black; more than twice as long as wide (3.5:1.5) and about one-eighth as wide as the head (1.5:12.0). Genovertical plates bare above the orbital bristle; narrow, and only subshining as in *capsicarum.* Inferior orbital setulae very closely placed, numbering 17 or 18; no hairs or setulae above the orbital bristle in side view. Anterolateral extremities of the frons, where each side merges with the corresponding parafacial, polished black. Mouth margin with three or four oral setulae, the lowermost strongly developed and vibrissa-like, i.e., subequal to the orbital bristle. As in *capsicarum*, with a definite gap between the stronger lower oral setula and the remaining hairs of the series above it. Lunule dark silvery pollinose; with eight setulae. Third antennal segment entirely dark brown to black; about twice as long as wide (3.66: 1.33). Plumosity of arista about one-half as wide as the width of the third antennal segment.

Thorax brownish-black, greasy-shiny through a relatively heavy coating of brown pollen. Mesonotum, behind the strong bristles, and the scutellum appearing velvety, deep golden-brown pollinose from an anterodorsal aspect. Bristling of the mesonotum strong, as in *capsicarum;* anterior pair of dorsocentrals almost as strong as the posterior pair, intra-alar bristle nearly equal in size to the anterior notopleural. Marginal setulae of the scutellum strong, in two rows posteriorly, largest setula dorsad of the principal row; apex of scutellum with six setulae between the bristles. Mesopleuron with four strong anterodorsal bristles and a weak, hair-like one in the same series both above and below the stronger ones; with three posterior mesopleural bristles; disc of mesopleuron relatively thickly and strongly setulose. Sternopleuron as in *capsicarum.* Prosternum with three or four hairs in two series on each anterolateral margin. Legs, including the tarsi, black; preapical dorsal bristles of the midtibiae relatively very strong, i.e., about equal in size to the preapical ventral tibial bristle opposite it; those of the front and hind tibiae scarcely stronger than the other tibial hairs. Calyptrae brown with darker brown fringe of hairs. Wings dusky-brown fumose with dark brown veins.

Abdomen dark brownish-black, the disc very heavily brownish pollinose, giving it a rich velvety appearance.

Genitalia as in Figs. 16, 20-22, and 25.

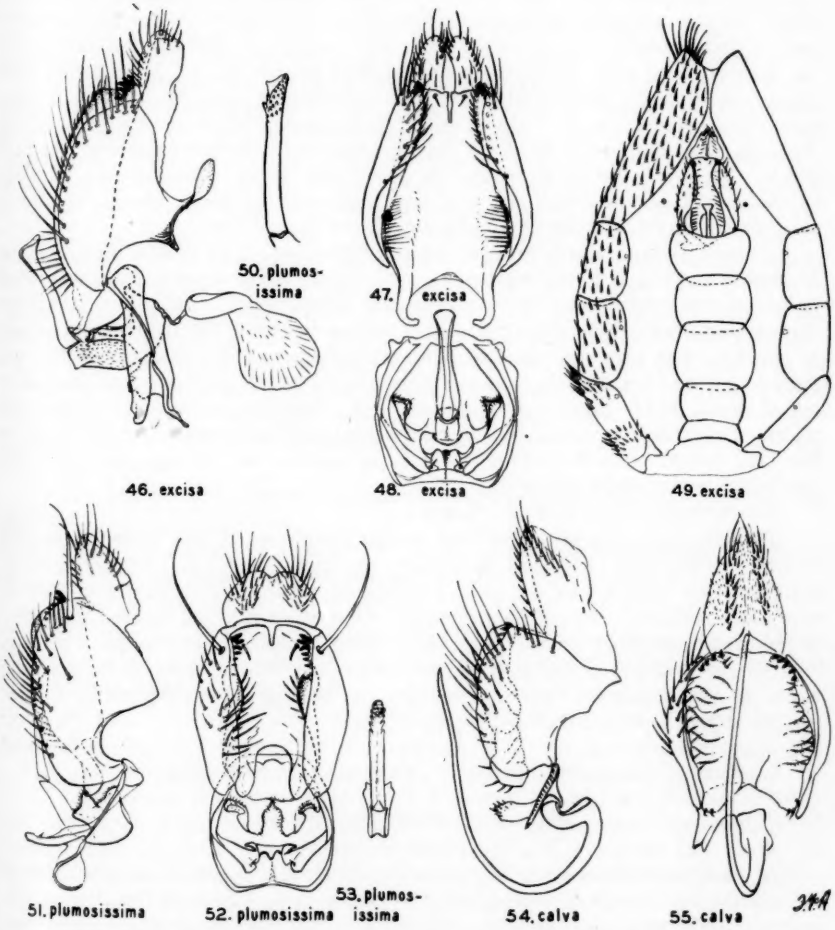
I have not seen the female of this species.

Material seen.— ♂, Cameron's Highlands, Malaya, 20.X.1928, G. H. Corbett, *Cucumus sativa* fruit, presented by Imp. Inst. Ent. to B. M., 1939-338, det. *Lonchaea citricola* Bezzi, (by) van Emden, 1939. ♂, Cameron's Highlands, Malaya, 25.5.1934, Entom. Div. Agric. Dept. 9628, larvae feeding on fruit of *Capsicum esculentum* Mill., det. *Lonchaea atratula* Wlk. (by) van Emden, 1938.

Atratula is closely related to *capsicarum* but differs from that species as follows: A larger, more pollinose species, with shorter antennae, wider frons, more anterodorsal mesopleural bristles, more setulae between the apical scutellar bristles, and darker wings; these characters all in addition to genitalic differences shown in Figs. 16, 20-22, and 25. See, also, remarks under *S. capsicarum*, and *S. ficiperda* (Bezzi).

According to Dr. J. R. Vockeroth, there are four specimens in the British Museum standing under the name *L. atratula* Wlk., none of which bear Walker's type label. It is possible that some of these are unlabelled typic material. Until this material can be critically examined, I have accepted Bezzi's (1920) concept of the species.

Hennig, (1941a) records what he considers to be *atratula* (Wlk.) from Formosa. I have no means at present of checking his material against my material and thus have not included the record in the list of synonymy above.



Figs. 46-55. *Silba* spp.; 46-49, *excisa* (Haragam, Ceylon), 46, right lateral aspect of male genitalia, 47, and 48, ventral aspect of male genitalia, 49, ventral aspect of male abdomen; 50-53, male genitalia of *plumosissima* (Nyala, Sierra Leone): 51, right lateral, and 52, ventral aspect (aedeagus not shown), 50, right lateral aspect of apical segment of aedeagus (greatly enlarged), 53, ventral aspect of aedeagus; 54, and 55, male genitalia of *calva* (part of internal genitalia torn away) (Coimbatore, S. India): 54, right lateral, and 55, ventral aspect.

Silba calva (Bezzi)

Figs. 54, 55

Lonchaea calva Bezzi, 1912, Philipp. J. Sci. 8: 319, 320-1 (type: ♀, Los Banos, Laguna Prov. Philippine Islands).

Lonchaea (*Carpolonchaea*) *calva* Bezzi, 1920, Bull. Ent. Res. 11 (3): 205, 210; Bezzi, 1928, Diptera of the Fiji Islands, p. 99 (Fiji Is.).

Somewhat smaller than *S. plumosissima* (Bezzi). Very lightly pollinose, shining black species. Plumosity of arista noticeably shorter than in most *Silba* species. One of the oral setulae rather weakly vibrissa-like. Calyptrae and fringes white. Tarsi entirely black or dark brown.

Male.—Superficially, very similar to *S. abstata* n.sp. but differing as follows: Frons narrower in relation to the head width (2.0:11.5), without any depression and entirely subshining, velvety black; with about 17 inferior orbital setulae on each side; no hairs above the orbital bristle in side view. Vibrissa-like oral setula not strongly differentiated, i.e., but little longer than the adjacent setulae; with three or four setulae above it. Third antennal segment longer, at least three times as long as wide (4.0:1.3); very narrowly reddish-brown at the base inside. Plumosity of arista distinctly narrower, about three-fourths as wide as the width of the third antennal segment; tapering from about the apical third to the apex; with about 17 plunules above and below.

Thorax shining black, without bluish reflections as in *abstata* new species. Mesonotum, behind the strong bristles, and the scutellum lightly aeneous-brown pollinose, this pollen being visible only under oblique light. Margin of scutellum with six or seven fairly strong marginal setulae between the bristles and a pair of weaker ones between the apical scutellar bristles. Mesopleuron with two strong and one weaker anterodorsal bristles and three posterior bristles. Preapical dorsal tibial bristles of mid and hind tibiae distinctly shorter than the width of the tibiae opposite the bristles; preapical ventral bristle of the midtibia but little longer than the width of the tibia opposite it. Wings, calyptrae and their fringes distinctly yellow.

Genitalia as shown in Figs. 54 and 55.

Female.—Agreeing with the male except as follows: Frons wider in respect to head width (3.0:11.0) and in respect to height (3.0:3.0); somewhat more pollinose and with a pair of weak converging fovae anteriorly, these grooves much less distinct than in *abstata* females. Ovipositor normal, tapered gradually to the apex with many yellow hairs on the long preapical section; apical section, near its base, with a dorsal pair of hairs, each hair about twice as long as the width of the ovipositor opposite its (the hair's) base and a subapical, ventral pair of approximately the same length.

Material examined.— ♂, ♀, Coimbatore, S. India, Sept., 1953, P. S. Nathan; ♀, Ammatti, S. Coorg., S. India, 3100′, Oct., 1952, P. S. Nathan.

Silba capsicarum new species

Figs. 17, 18, 23, 24, 26

A medium-sized species, somewhat smaller than *S. plumosissima* (Bezzi) but a little larger than *S. excisa* (Kert.). With dirty yellowish hyaline wings, brownish calyptrae and fringes, and black tarsi. Other external characters serving to distinguish the species are: its relatively long antennae with moderately short-plumose arista; the mesopleuron with three long anterodorsal bristles and three posterior ones, and the weak vibrissa-like bristle among the oral setulae.

Male.—Frons more than twice as long as wide (4.0:1.5), and barely less than one-eighth head width (1.5:12.5); weakly silky-shiny; black posteriorly becoming mahogany-brown at the lunule; genovertical plates narrow, bare, and

very little more shining (black) than the frons. About 23 or 24 inferior orbital setulae on each side below the orbital bristles; no setulae above the orbital bristles. Mouth-margin with four or five closely placed oral setulae, the lowermost weakly vibrissa-like; this short row of oral setulae separated from the subgenal hairs and setulae below, by a short, but distinct, gap—as if two or three lower oral setulae were missing. (This condition is a normal one.) Lunule dark brown in ground colour, silvery pollinose, and with eight setulae. Third antennal segment three times as long as wide (3.75:1.25); entirely dark brown. Plumosity of arista not as wide as third antennal segment (0.9:1.25). Palpi slightly narrower than the third antennal segment.

Thorax greasy-black with a faint bronze lustre; thinly brownish-pollinose above. Mesonotum, behind the strong bristles and the scutellum more heavily brownish pollinose than anteriorly, but the pollen evident from oblique anterior views only; in dorsal view the scutellum strongly shining; dark bronze in colour. Bristles of the mesonotum somewhat stronger than usual as in *atratula;* intra-alar bristle subequal to the posterior notopleural bristle. Scutellum with three or four lateral setulae and four apical setulae in addition to the four bristles. Mesopleuron with three (sometimes two) strong anterodorsal bristles, with a hair-like one below them, and several setulae above them; posteriorly with three strong posterior bristles, with a hair-like one below them. Anterior sternopleural bristle subequal to the posterior one; sternopleuron conspicuously setulose anteroventrad of the strong bristles but bare behind them. Antero-lateral margins of the prosternum with four or five hairs on each side. Legs entirely dark brown or black; midtibia with a strong preapical dorsal bristle, i.e., at least as long as the maximum diameter of the midtibia and subequal to the apical ventral bristle; preapical dorsal bristles of the front and hind tibiae very weak, i.e., little stronger than the normal tibial hairs. Calyptrae sandy-brown; margins and fringes dark brown. Wings dirty yellowish hyaline; veins brownish-yellow.

Abdomen mostly shining above, not conspicuously velvety pollinose on the disc.

Genitalia as illustrated in Figs. 17, 18, 23, 24 and 26; the aedeagus (Figs. 17 and 23) being perhaps the most distinctive feature of this species.

Female.—Unknown.

Holotype.—♂, Khumpur, Malaya, 23.IX.1935, Entom. Div., Agric. Dept., (host:) *Capsicum manicatum* (?), det. *Lonchaea* n.sp. nr. *ficiperda* Bezzi (by) Van Emden, 1938.

Paratype.—♂, Kuala Lumpur, Malaya, 19.X.1926, (host:) *Capsicum* sp., G. H. Corbett.

Holotype and paratype in the British Museum (Natural History).

S. capsicarum is closely related to *S. ficiperda* (Bezzi) and *atratula* (Wlk.). All three species are easily separated on the basis of genitalic characters but it is more difficult to do so from external characters. *Capsicarum* can usually be separated from *ficiperda* by the former's larger size, longer antennae, lighter coloured wings and more setulose scutellum; from *atratula* it can be distinguished by its relatively weaker vibrissa-like bristle, its lighter coloured wings and less pollinose abdomen. See, also, remarks under *atratula* and *ficiperda.*

***Silba chalkei* new species**

Figs. 1, 27, 28

A small-sized, rather unusually shiny species with light steel-blue reflections as opposed to the usual metallic blue-black highlights. All the metatarsi, at

least, yellowish. Mesopleuron with three anterodorsal macrochaetae; scutellum with three lateral setulae on each side and a pair of apical setulae in addition to the usual four scutellar bristles. Wings almost clear hyaline with pale yellow veins. Calyptrae white with pale silky fringes; larger than usual in the family.

Male.—Frons (Fig. 1) wide for this sex, about one-third longer than wide (3.0:2.0) and two-ninths as wide as the total head width (2.0:9.0). The type specimen with a pair of relatively broad, shallow grooves beginning in front of the orbital bristles and converging to the middle of the upper margin of the lunule; also with a narrower groove immediately laterad of each of these grooves appearing under low magnification (40X) as a linear, shiny, streak from which arises a row of about 13 inferior orbital setulae; with a transverse depression immediately in front of the ocellar triangle. (It is possible that these grooves and depression have been caused by shrinkage of the specimen but they appear to be normal conditions, at least in dried specimens.) Genovertical plates shiny, but not highly polished; with steel-blue reflections. Parafacials, genae, face and lunule lightly, cinereous pollinose. Parafacials linear; distance between oral margin and eye narrow, about equal to the width of a palpus. Oral margin with three or four weak oral setulae, none being vibrissa-like. Lunule (Fig. 1) brownish in ground colour, with six setulae, only, visible in the type. First and second antennal segments mostly orange-brown in colour. Both the third antennal segments missing from the type but, on the basis of the orange-brown colour of the basal segments, the third segment probably orange to orange-brown, at least at the base inside.

Thorax strongly shining; blue-black with light steel-blue highlights. Mesonotum very lightly pollinose on the disc but distinctly cinereous pollinose behind the strong mesonotal bristles; scutellum, likewise, more heavily pollinose. Major macrochaetae of the mesonotum strong but the setulae short and appressed. Intra-alar bristle weak, i.e., not as strong as the dorsal bristle of the second antennal segment. Margin of scutellum with three setulae and one pair of apical setulae in addition to the usual four bristles. Pleurae entirely and distinctly cinereous pollinose. Mesopleuron with three anterodorsal and three posterior bristles; with a weak seta below the three strong posterior bristles. Anterior sternopleural bristle but little more than one-half as strong as the posterior one. Prosternum with four hairs in a loose cluster at each anterolateral angle.

Femora and tibiae black; preapical dorsal bristle of front tibia weak and hair-like, those of the mid and hind tibiae approximately as long as the diameter of the tibia opposite the setal insertion. Front and midtarsi with the first two segments entirely, and basal part of the third, brownish-yellow; hind tarsus with the first segment entirely, and basal part of the second, brownish-yellow; remaining tarsal segments dark brown to black in colour.

Wings clear hyaline with yellow veins. Third and fourth veins almost parallel at their apices, definitely not divergent. Calyptrae white; fringes pale; rather larger than is usually found in the family.

Abdomen shining steely-blue as in the thorax, with a light coating of cinereous pollen in the middle of the basal terga.

Genitalia as in Figs. 27 and 28.

Female.—Unknown.

Holotype.—♂, Oesong dong, Chipor, Korea, 26.V.1952, F. C. R. Chalke, type number 6275 in the Canadian National Collection.

I take pleasure in naming this species in honour of Major F. C. R. Chalke who generously devoted some of his leisure time to collecting flies for the Canadian National Collection while he was stationed in Korea.

There are three, only, known species of *Silba* from the Old World which have yellowish or yellowish-brown tarsi, i.e., *S. pallicarpa* (Bezzi), and *S. chalkei* n.sp. from Korea. All run to *pallicarpa* in Bezzi's (1920) key. For distinguishing characters see under *S. admirabilis* above.

Silba excisa (Kertész)

Figs. 46-49

Lonchaea excisa Kertész, 1901, Term. Füset. 24: 87 (type: ♂, Singapore); de Meijere, 1908, Tijdschr. v. Ent. 51: 133 (Semarang); de Meijere, 1910, Tijdschr. v. Ent. 53: 118, table 7, Fig. 50 (W. Java); de Meijere, 1918, Tijdschr. v. Ent. 60: 350 (Semarang); Bezzi, 1918, Bull. Ent. Res. 9: 246 (Philippines, Seychelles).

Lonchaea (*Carpolonchaea*) *excisa* Kertész, Bezzi, 1920, Bull. Ent. Res. 11: 209 (Ceylon, India, Java, Philippines, Simalur).

Carpolonchaea excisa (Kertész), Hennig, 1941, Arb. Morph. Taxon. Ent. Berlin-Dahlem 8: 18-19 (Sunda Is.); Hennig, 1941, Entomolog. Beihefte 8: 145 (Formosa).

Lonchaea plumata Lamb, 1912, Trans. Linn. Soc. London 15 (3): 303-305, text fig. 1, pl. 15, Figs. 1, 2 (type: ♂, Seychelles); Bezzi, 1918, Bull. Ent. Res. 9: 242 (= *excisa* Kert.).

This species easily distinguished from others in the genus by reason of the distinctive characters in the male abdomen, i.e., apparent last segment elongate, deeply excised at the apex and with many stout bristles along the margin of the excision (Fig. 49).

Male.—Frons rather broad, about five-sevenths as wide as long (2.5: 3.5) and almost one-third as wide as the head (2.5: 9.0); from 11 to 13 inferior orbital setulae on each side. Oral setulae almost uniform in length, the vibrissa-like bristle scarcely stronger than the three or four setulae above it. Third antennal segment 2½ times as long as wide (3.1: 1.25); sometimes narrowly reddish-brown at the base, inside. Plumosity of the arista slightly wider than the width of the third antennal segment, with about 17 plunules above and below. Lunule with about eight setulae, i.e., one above and three below, on each side. Thorax and abdomen shining black, without definite bluish reflections. Mesonotum, behind the strong dorsocentrals, and the scutellum distinctly cinereous pollinose. Scutellum with three or four weak marginal setulae on each side and an apical pair in addition to the four bristles. Mesopleuron with four anterodorsal bristles, the lowermost one weak, and three posterior bristles. Prosternum with three or four fine hairs anteriorly on each lateral margin.

Legs including tarsi entirely black; mid and hind tibiae each with a distinct preapical dorsal bristle, that of the midtibia subequal in length to the width of the tibiae opposite the bristle.

Calyptrae and fringes very pale yellow. Wings varying from almost clear hyaline to yellowish-hyaline. Fifth (apparent last) segment of the abdomen (Fig. 49) about 1½ times as long as the fourth; deeply excised at the apex; margins of the excision with numerous, stout bristles.

Genitalia as shown in Figs. 46-48.

Female.—Unknown to me.

Material examined.—♂, Ceylon, Haragam, 28.V.92, Lt. Col. Yerbury, 1892-192; ♂, Malaya, Cameron Highlands, 25.V.1934, Ent. Div. Agr. Dept., 9628, larvae feeding on fruit of *Lycopersicum esculentum;* ♂, Ammati, S. Coorg., S. India, 3100′, Oct. 1952, P. S. Nathan.

According to Dr. J. R. Vockeroth, the type of this species is in the British Museum (Natural History).

Silba ficiperda (Bezzi)

Figs. 13-15, 19

Lonchaea ficiperda Bezzi, 1913, Philipp. J. Sci. 8 (D): 320 (type: ♂, Philippine Is.).
Lonchaea (Carpolonchaea) ficiperda Bezzi, 1920, Bull. Ent. Res. 11: 207 (Philippine Is.).

A relatively small species with black tarsi and brown calyptrae; differing from *S. atratula* (Wlk.) and *S. capsicarum* n.sp. by its short plumose arista, very fine, almost indistinguishable preapical, dorsal tibial bristles, distinctive genitalic characters, and by the absence of a vibrissa-like oral setula.

Male.—Frons narrow, at the narrowest point about one-sixth as wide as the head (1.5: 9.0); twice as long as wide (3.25: 1.5); dull brownish-black in colour with narrow, subshining, black, genovertical plates; with about 18 inferior orbital setulae on each side. Oral margin with a uniserial row of uniformly long oral setulae, none being vibrissa-like. Lunule silvery pollinose; with eight setulae, i.e., one above and three below on each side. Third antennal segment slightly more than twice as long as wide (2.5: 1.2); reddish-brown at the base inside. Plumosity of arista narrow, i.e., about two-thirds as wide as the width of the third antennal segment.

Thorax and abdomen black or brownish-black with faint bluish reflections in some lights. Mesonotum greasy-shiny; thinly covered with brownish pollen. (Bezzi's statement couplet 9, p. 205, 1920 "thorax and scutellum never pollinose" does not hold under close examination.) The mesonotum, behind the strong dorsocentrals, and the scutellum distinctly golden-brownish pollinose. (This colour of pollen, in contrast to the usual silvery or cinereous pollen, makes the pollen more difficult to see but it is undoubtedly present in *ficiperda;* it is also present in such related species as *atratula* (Wlk.) and *capsicarum* n.sp.) Scutellum with three or four weak marginal setulae on each side, and an apical pair, in addition to the usual four bristles. Mesopleuron with three strong anterodorsal mesopleural bristles and with the same number of strong posterior ones. Anterior sternopleural bristle rather weak, distinctly weaker than the posterior one. Prosternum with three or four fine hairs on each anterolateral margin.

Legs entirely dark brown to black with rather weak preapical dorsal bristles on the mid and hind tibiae, that of the midtibia scarcely as long as the width of the tibia opposite the seta's base; the one on the hind tibia much weaker.

Calyptrae and their margins and fringes brown. Wings light brownish fumose with brownish veins.

Genitalia as in Figs. 13-15, and 19.

Material examined.— ♂, Los Banos, Philipp. Is., 1913-355, P. I. Baker.

This species may be closely related to *S. cupraria* (de Meijere) but, according to the description, it differs in colour and in the width of the frons. From de Meijere's figure of the male genitalia of *cupraria,* however, it appears that the two species are distinct. There is a close phylogenetic relationship between *ficiperda, atratula* and *capsicarum.* For a summary of the external differences between these latter three species see under descriptions of *capsicarum.*

A cotype of this species, and one other specimen of the same series, is in the British Museum (Natural History).

Silba filifera (Bezzi)

Figs. 36, 37, 45

Lonchaea filifera Bezzi, 1913, Philippine Journ. Sci. 8 (D): 320 (type: ♂, Philippine Is.).
Lonchaea (Carpolonchaea) filifera Bezzi, 1920, Bull. Ent. Res. 11: 206, 209, 210 (Philippine Is.; Laguma, Los Banos, Luzon, Manilla, Mt. Maquiling); Bezzi, 1928, Diptera Brachycera and

Athericera of the Fiji Islands, p. 99 (Fiji Is.: Labasa, Lautoka, Natova); Malloch, 1930, Insects of Samoa 6 (6) 240, 241, Fig. 1a, 1b (Samoa).

Carpolonchaea filifera (Bezzi), Bohart *et al.*, 1951, B. P. Bishop Mus. Bull. 204: 96, pl. 4: 11 (Guam) (larvae in pig manure).

Carpolonchaea setifera de Meijere, Hennig, 1941, Arb. morph. taxon. Ent. Berlin-Dahlem 8: 19, Fig. 1 (Sunda Is.: Flores, Lombok, Soembawa).

This species with the following combination of characters: Clear wings, third antennal segment twice as long as wide, plumosity of arista a little wider than width of third antennal segment, vibrissa-like bristle present, two anterodorsal mesopleural bristles, and moderately strong preapical dorsal bristles on mid and hind tibiae.

Male.—Frons silky-shiny except from an anterior view; about twice as long as wide (3.5:2.0); about one-fifth as wide as total head width (2.0:10.5); with 15 inferior orbital setulae. Genovertical plates as wide as distance between bases of the antennae; bare with steely-blue reflections. With from four to six oral setulae, the lowermost distinctly vibrissa-like, i.e., about as strong as the dorsal bristle of the second antennal segment. Lunule strongly silvery pollinose over a dark brown or black ground colour; usually bearing six (sometimes eight) setulae, i.e., two below and one (sometimes two) above on each side. Third antennal segment entirely dark, about twice as long as wide (2.5:1.25); plumosity of arista slightly wider than the width of third antennal segment.

Mesonotum greasy-shiny anteriorly but distinctly cinereous pollinose behind the strong bristles; ground colour black with weak blue-black reflections. Scutellum heavily pollinose with iridescent, bronzy reflections. Intra-alar bristle weak, but little stronger than the vibrissa-like oral setula; margin of scutellum usually with from four to six lateral setulae, apex usually with four weak setulae between the strong bristles. The entire pleuron rather heavily cinereous pollinose. Mesopleuron with two anterodorsal bristles, and a hair-like one below them; with three posterior bristles. Anterior sternopleural bristle much weaker than the posterior one. Prosternum with four hairs on each anterolateral angle.

Legs entirely blackish in colour; preapical dorsal bristle of front tibia very weak, hardly distinguishable from the hairs; those of the mid and hind tibiae subequal in size, almost as long as the width of the tibia opposite each bristle respectively.

Wings almost clear, with pale yellow veins. Calyptrae white with concolourous margins and fringes.

Abdomen distinctly cinereous pollinose on the disc from some oblique views but also plainly shining, particularly at the sides, in other views; black in ground colour with blue-black reflections.

Genitalia, as shown in Figs. 36, 37, 42-45.

Material examined.— ♂, Nuku'alofa, Tonga Islds., 10.V.1949, I.D. 52, B. A. O'Connor, swept from sweet potato crop, Com. Inst. Ent. Coll., No. 11569, pres. by Com. Inst. Ent. B. M. 1950-16 det. *Lonchaea* (*Carpolonchaea*) *filifera* Bezzi (by) Van Emden, 1950; ♂, Parak, Malaya, 8.II.1927, ex *Cocas rucifera* (dead bud), 3701, G. H. Corbett, pres. by Imp. Inst. Ent. B. M., 1939-338, det. *Lonchaea filiferal* Bezzi (by) van Emden, 1939; ♂, Parak, Malaya, *Cocos rucifera*, decayed young bud, 3701, G. H. Corbett, pres. by Imp. Bur. Ent. Brit. Mus., 1927-279; ♂, Kuala Lumpur, Malaya, 18.IV.1929, Entom. Div., G. H. Corbett, larvae in fruits of *Cucumes sativa*, 6096, pres. by Imp. Inst. Ent. B. M., 1939-563; ♂, Pahang, Malaya, 24.VII.1931, Entom. Div. Agric. Dept., ex decaying cobs of *Zea mays*, pres. by Imp. Inst. Ent. Brit. Mus., 1932-42, det. *Lonchaea ? pollinosa* Kert. (by) G. A. Marshall.

Further study of this species may reveal that it is a composite of two or more subspecies. In the male from the Tonga Islands, the posterior gonopophyses appear undeveloped in side view compared with the same structures in Malayan specimens. (Compare Fig. 36 with Fig. 42 and Fig. 44 with Fig. 45.)

See remarks under *S. setifera* (de Meijere) which concern Hennig's (1941) determination of *S. filifera.*

Silba fraterna new species

Figs. 34, 35

A moderately large species, similar in general habitus to *S. ophyroides* (Bezzi). Compound eyes more densely and longer pubescent than in any other *Silba* species seen. Plumosity of arista narrower than in any other member of the genus known to me. Frons with a pair of outstanding interfrontal setae a short distance above the lunule. Vibrissa-like bristle strong. Mid and hind tibiae each with a relatively strong preapical dorsal bristle. Tarsi black. Calyptrae white with yellowish fringes.

Male.—Compound eyes sparsely but uniformly pubescent, the hairs plainly evident under low magnification (40X); most hairs distinctly longer than the diameter of the largest ommatidia or about twice as long as the smallest ones; on the average, with four or five ommatidia between any two hairs. Frons about three-fourths as wide as long (3.0:4.0); almost one-fourth as wide as the head (3.0:13.1); subshining black; uniformly dusted with cinereous pollen; with an irregular transverse concavity in front of the ocellar triangle and the oribtal bristles; near the lower (anterior) margin with a pair of strongly developed interfrontal setulae, i.e., approximately as long and as strong as the dorsal bristle of the second antennal segment, which project forward over the sides of the lunule for at least one-half their length; with 12 or 13 inferior orbital setulae on each side. Genovertical plates shining steely-blue; no hairs above the orbital bristle in side view. Post-ocellar bristles stronger than usual in the family, i.e., at least as long and strong as the dorsal bristle of the second antennal segment; parallel or slightly convergent. Lunule brownish-orange in ground colour; silvery pollinose; bearing 10 setulae, i.e., two above and three below on each side. Parafacials nearly linear; heavily dusted with cinereous pollen. One of the oral setulae roughly twice as long and strong as any of the others; three or four weak setulae above it and approximately the same number below it. Third antennal segment three times as long as wide (4.5:1.5); uniformly dark brown in colour. Plumosity of arista narrower than in any other *Silba* species seen, i.e., barely one-half as wide as the width of the third antennal segment. Palpi as usual, flattened, bristled, and black.

Mesonotum lightly pollinose anteriorly but more heavily so posteriorly; not brilliantly polished but rather strongly shining; black in ground colour with aeneous-green or -blue reflections. Scutellum heavily pollinose; weakly shining, with bronzy highlights. Intra-alar bristle about as strong as the inner humeral bristle; other bristles of the mesonotum normal. Scutellum with four lateral setulae on each side and an apical pair, these in addition to the usual four bristles. Pleurae uniformly cinereous pollinose; mesopleuron appearing more aeneous than the other pleural sclerites. Three strong anterodorsal and three strong posterior mesopleural bristles; anterior sternopleural bristle little weaker than the posterior one; no setulae behind the posterior sternopleural bristle. Propleuron with three or four hairs on each side anteriorly.

Legs and tarsi black; preapical dorsal bristle of midtibia sub-equal to the ventral bristle opposite it; that of the hind tibiae weaker; the one on the front tibiae scarcely distinguishable from the hairs.

Wings pale; creamy-hyaline, with pale yellow veins. Calyptrae white, with pale yellow margins and fringes. Halteres with black knobs and yellowish stalks.

Abdomen cinereous pollinose on the disc; subshining aeneous-black in colour.

Genitalia as illustrated (Figs. 34, 35).

Female.—Frons at least as wide as long (4.1:4.0); interfrontal hairs, which have become bristles in the male, but little stronger than the others in the female.

Ovipositor rather bluntly rounded apically; last segment with a pair of short, sub-basal hairs on the dorsal side, and a longer, i.e., almost as long as the apical segment, lateroventrally-directed pair near the apex.

Otherwise the female agreeing with the description given for the male.

Holotype.— ♂, Nairobi, (Kenya) July, 1930, van Someren. pres. by Imp. Inst. Ent. B. M., 1939-338, det. *Lonchaea* (*Carpolonchaea*) *laevis* (by) van Emden, 1938.

Allotype.— ♀, Port Elizabeth, Cape Prov., June, 1944, G. N. Hepburn, S. N. 2516, ac. PE. 195, ex ripening tomatoes, pres. by Imp. Inst. Ent. B. M., 1946-301.

***Silba ophyroides* (Bezzi)**

Figs. 32, 33

Lonchaea (*Carpolonchaea*) *ophyroides* Bezzi, 1920, Bull. Ent. Res. 11: 201, 203-4 (type: ♂, Br. East Africa; species recorded from N. Nigeria also).

A large species with black tarsi, whitish calyptrae, a pair of strong vibrissa-like oral setulae and brassy-green abdomen; wings large and fairly distinctly yellowish fumose anteriorly.

Male.—Very similar to *plumosissima* except as follows: Frons about three-fourths as wide as long (4.0:3.0) and about one-fourth head width (3.0:12.5); dull black in colour; very feebly shining in comparison with that of *plumosissima;* each side with 17 or 18 inferior orbital setulae. Oral margin with a row of four or five oral setulae, the lowermost distinctly vibrissa-like, i.e., nearly as strong as the orbital bristle. Lunule orange-brown in ground colour with six setulae, i.e., two stronger ones below and one above on each side. Third antennal segment about 2⅔ as long as wide (4.0:1.5), otherwise much as in *plumosissima.* Plumosity of arista somewhat narrower than that of *plumosissima.*

Scutellum more distinctly brassy-green than in *plumosissima.* Intra-alar bristle stronger than the dorsal bristle of the second antennal segment but weaker than the notopleurals. Mesopleuron with four strong anterodorsal bristles and three posterior ones. Prosternum with four or five fine hairs on each antero-lateral margin.

Preapical dorsal bristle of midtibiae strong, i.e., longer than the width of the tibia opposite the base of the bristle, but not as long as the apical ventral bristle on the same tibia; those on the front tibia hardly distinguishable among the hairs, and that of the hind tibia weak, i.e., not as long as the width of the tibia.

Wings appearing oversized for the species; distinctly yellowish-fumose on the anterior half; veins yellowish. Abdomen more shining than in *plumosissima;* aeneous-green to bluish-black in colour.

Genitalia as in Figs. 32 and 33.

Female.—Agreeing with the male except for the usual sexual differences. The frons at least as wide as long (3.6:3.5) and between one-fourth and one-third as wide as the head (3.6:12.5); somewhat more shining in the female than in the

male; bearing from 13 to 15 inferior orbital setulae; often with several setulae on the frontal vitta dorsad of the orbital bristle in the females.

The hairs near the apex of the ovipositor all shorter than the width of the apical segment of the ovipositor.

Material examined.– ♂, Kampala, Uganda, 5.IX.1918, No. 6524, C. C. Gowdey, det. *Lonchaea plumosissima* Bezzi (by) J. R. Malloch, pres. by Imp. Inst. Ent. to B. M., 1933-414; ♂, ♀, Dwoli, Uganda, 13.XII.1929, H. Hargreaves, pair in cop., pres. by Imp. Inst. Ent. B. M., 1939-338, det. *Lonchaea* (*Carpol.*) *ophyroides* Bezzi (by) van Emden, 1938; ♀, Serere, Uganda, Oct., 1937, A. M. Gwynn, G. 102, ex rotting tomato, pres. by Imp. Inst. Ent. B. M., 1947-13.

The type of *ophyroides* (Bezzi) is in the British Museum (Natural History).

***Silba plumosissima* (Bezzi)**

Figs. 50-53

Lonchaea plumosissima Bezzi, 1918, Bull. Ent. Res. 9: 247-8, Figs. 1 and 3 (type: ♂, Aburi, Gold Coast; species recorded also from French Guinea and Dahomey).

Lonchaea (*Carpolonchaea*) *plumosissima* Bezzi, 1920, Bull. Ent. Res. 11: 204, 206, 209, 210, (Gold Coast).

The following features of this species are not adequately described in Bezzi's description of the species:

Male.–Frons relatively broad, about 1⅓ as long as wide (4.0:3.0) and about one-fourth as wide as the head (3.0:12.3); approximately 17 inferior orbital setulae on each side. With five oral setulae, the lowermost distinctly vibrissa-like. Lunule dark brown; with at least six setulae, i.e., two above and one below on each side. Third antennal segment about 2½ times as long as wide (3.8:1.5); entirely dull brownish-black in colour. Plumosity of the arista relatively very broad but distinctly less than twice as wide as the width of the third antennal segment (1.5:2.0). (This is also true of Bezzi's (1918) figure of the head of the female, in spite of his statement to the contrary.)

The intra-alar bristle about as strong as the dorsal bristle of the second antennal segment, i.e., distinctly weaker than the notopleural bristles. Mesopleuron anteriorly with three strong anterodorsal bristles and sometimes with a weaker fourth one below them; posteriorly with three strong posterior bristles. Prosternum with several hairs on each of the anterolateral angles.

Preapical dorsal bristles of mid and hind tibiae subequal in length and moderately strong, i.e., about equal in length to the width of the tibiae at the bases of the bristles; those on the front tibiae scarcely distinguishable from the other hairs.

Genitalia as shown in Figs. 50-53.

Material examined.– ♂,Myala, Sierra Leone, 17.IX.1930, ex tomato, E. Hargreaves, pres. by Imp. Inst. Ent. to B. M. 1934-137.

S. plumosissima is difficult to separate from *S. ophyroides* (Bezzi) and *S. laevis* (Bezzi) by the use of external characters only. Its more shining frons, weaker vibrissa-like bristle, more hyaline wings and smaller size help distinguish it from the former; its broad aristal plumosity serves to separate it from specimens of *laevis*. An examination of the male genitalia, however, leaves no doubt as to their identity.

I am reluctant to accept Bezzi's (1920) records of this species from Br. East Africa and the Philippine Islds.

The type of *plumosissima* Bezzi is intact in the British Museum (Natural History).

B & Z Library

Silba setifera (de Meijere)

Figs. 38-41

Lonchaea setifera de Meijere, 1910, Tijdschr. v. Ent. 53: 119, pl. 7, fig. 52 (type ♂, Java: Semarang; species also recorded from Batavia: Pangerango); 1918, Tijdschr. v. Ent. 60: 350 (New Guinea: G. Gedeh, G. Ungaren, Salatigo, Wanosobo).

Lonchaea (*Carpolonchaea*) *setifera* de Meijere, Bezzi, 1920, Bull. Ent. Res. 11: 209 (Philippines: Leyte, Los Banos, Manila, Mt. Maquiling, Tacloban).

Carpolonchaea filifera Bezzi, Hennig, 1941, Arb. morph. taxon. Ent. Berlin-Dahlem 8: 19, 20, Figs. 2, 3 (Sunda Islds.).

A relatively small species (approximately three mm.) with black tarsi, white calyptrae and clear wings. The male with a group of long curved bristles at each side of the apparent last abdominal segment (Fig. 41). The mesopleuron with two anterodorsal bristles and three posterior ones. The preapical dorsal bristles of the front and hind tibiae hair-like and almost indistinguishable, but that of the midtibiae about as long as the width of the tibia opposite the base of the bristle.

Male.—Frons lightly silvery pollinose, silky-shining in most lights; about 1¾ as long as wide (3.5:2.0) and about one-fifth as wide as the head (2.0:9.5); distinctly narrowed anteriorly. Genovertical plates relatively broad; rather weakly shining with dark blue reflections. In the male specimen before me the row of inferior orbital setulae appearing interrupted below the dorsal five or six setulae, as if four or five of the setulae were broken off on each side. (This may or may not be a normal condition.) oral margin with about six oral setulae, these becoming increasingly stronger dorsoventrad, but none particularly vibrissa-like. Entire face, parafacials and lunule silvery pollinose; lunule apparently with only one setula below on each side. (Probably there are more above but they aren't visible in my specimen.) Antennae "nearly reaching the mouth margin" according to Meijere (1910), but the third segments missing in the male before me; second segment orange-brown; therefore the third segment probably orange-brown at the base inside.

Thorax greasy black with very slight indications of blue-black highlights. Mesonotum, posteriorly, and scutellum distinctly iridescent, cinereous pollinose. Intra-alar bristle about equal in size to the outer vertical bristle. Scutellum with four lateral setulae on each side and one pair of apical setulae in addition to the four bristles. Pleuron uniformly lightly pollinose. Mesopleuron with two anterodorsal and three posterior bristles; anterior sternopleural bristle but slightly weaker than the posterior one; prosternum with five hairs anterolaterally on each side.

Legs and tarsi unicolourous dark brown or black; preapical dorsal bristles of front and hind tibiae hair-like, scarcely distinguishable; that of the midtibia as long as the width of the tibia opposite the base of the bristle. Wings hyaline, with a slightly yellowish tinge; veins pale yellow. Calyptrae white with pale fringes.

Abdomen black; greasy-shiny apically and on the sides, the disc distinctly cinereous pollinose at the base; last apparent segment with a group of longer, incurved setaceous hairs, on each side of the apical portion (Fig. 41).

Genitalia as shown in Figs. 38-40.

I have not seen a female which I can definitely assign to this species.

Material examined.— ♂, Taiping, Malaya, 7.X.1925, ex leaves of African oil palm, G. H. Corbett, 2830, pres. by Imp. Inst. Ent. B. M., 1946-263, det. *Lonchaea setifera* de Meij. (by) van Emden, 1940.

S. setifera, like *S. excisa* (Kert.), is one of the better characterized species of the genus. Hennig (194la) evidently identified the species correctly as is indicated by the first sentence of his discussion under "*C. filifera*" but by some means, probably undetected typographical errors, the two names *setifera* and *filifera* are interchanged in the final statements of the paragraph, and also in the captions to the figures.

Acknowledgments

I am very grateful to Mr. N. D. Riley of the British Museum (Natural History) for making available to me specimens from that institution. I wish also to thank Dr. G. Sacca of the Instituto Superiore di Sanita, Rome, for generously loaning me his collection of Lonchaeidae. Also, I am indebted to Dr. J. R. Vockeroth of the Entomology Division, Ottawa, for comparing specimens and preparing a list of the lonchaeid material in the British Museum (Natural History).

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(Received June 7, 1956)

Preliminary Notes on Intersexes and Gynandromorphs of the Larch Sawfly[1]

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Sex anomalies have been used in an attempt to homologize the male and female genitalia of insects. Studies of some sex anomalies (Michener, C. D., Ann. Ent. Soc. Am. 37:336-351.1944) suggest that the second valvifers are homologous with the gonocoxites (phallobase); the second valvulae probably are homologous with the penis valves; and the third valvulae are homologous with the gonostyli (parameres). Homologues of the first valvifers and first valvulae of the female are absent in the males of Pterygota.

The external genitalia of a number of gynandromorphs and intersexes of the larch sawfly, supplied by J. A. Muldrew, have been examined with reference to these suggested homologies. This material emerged from cocoons collected in 1953 and 1954 at Riding Mountain National Park in Manitoba and Prince Albert in Saskatchewan, and shows variations in size, colour, and morphological structure.

Some specimens were typically male in their primary sexual characters, but were more typically female in colour of antennae, head, and legs. Another specimen showed the typical male coloration on one half of the head, and the female coloration on the other half of the head as well as the legs. Other specimens were primarily female, but showed male characteristics in the coloration of antennae, head, and legs.

Morphological variations in the external genitalia indicate that the first three of the following six sex anomalies had complete male genitalia in addition to parts of the female ovipositor. The genital capsule, however, had not revolved through a 180° angle as in the typical males.

Specimen 1. Hypandrium split down the centre; third valvula, first and second valvifers on the right side only.

Specimen 2. First valvula present under the hypandrium on the left side; rudimentary third valvula attached to the hypandrium on the right side.

Specimen 3. First valvifer, rudimentary second valvifer, and third valvula attached to the lateral half of hypandrium on the left side; a complete lateral half of the female ovipositor present on the right side.

The remaining three specimens also had parts of the female ovipositor but did not have complete male genitalia.

Specimen 4. Complete lateral half of the male genitalia on the left side; complete lateral half of the female ovipositor on the right side.

Specimen 5. Hypandrium split; lateral half of the male genitalia and what appears to be the first and second valvifers on the right side; only a rudimentary third valvula attached to the hypandrium on the left side.

Specimen 6. First and second valvifers, second valvula, rudimentary third valvula, two parameres, with the outer one being the smaller of the two, on both sides; phallobase, penis valve, and a definitive paramere only on left side.

A study of these gynandromorphs and intersexes does not support the above suggested homologies because of the presence in whole or in part of the male genitalia, in addition to components of the female ovipositor on the same side of the body.

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(Received February 3, 1956)

On the Tibial Comb of the Ceratopogonidae (Diptera) and Its Use in the Determination of the Neartic Species of *Culicoides*[1]

By FRANKLIN B. LEWIS[2]

Introduction

Recent studies of the genus *Culicoides* have exposed many new species and presented taxonomists with a difficult problem in using accepted characters or obtaining new differentiating characters clear-cut enough to provide suitable separation.

One such new character is the tibial comb, a structure found on the distal tip of the hind tibia of both sexes of ceratopogonid midges. Fox (1952) illustrated the tibial comb of several Puerto Rican *Culicoides* and (in litt.) suggested that this character might prove useful in separating other species of this genus. The present study appears to bear out this suggestion. Moreover the study indicates that the character might prove useful in other genera as well.

Methods

The tibial comb is identical in both sexes. The comb is composed of from four to sixteen stout, slightly curved long spines radiating from the distal tip of the hind tibia in spread-finger fashion. Interspersed among the long spines are shorter and more numerous spines. These smaller spines may be slender or broad-bladed. The smaller spines are more nearly uniform in length than are the long spines.

Since male specimens are usually smaller than females, and since a wide range of size variation was encountered in long series of female specimens, it was felt that ratios of the lengths of the long spines one to another and to the tibial width at the distal tip would be more reproducible than raw measurements. Size differentials would thus be eliminated through the use of ratios.

All of the long spines were measured in a straight line from the spine socket on the tibia to the distal tip of the spine. Spine curvature was not taken into account as nearly all the spines curve in a similar arc. The width of the tibia was measured across the distal tip from the base of the outermost anterior small spine to the base of the outermost posterior small spine. (Figure 1). The posterior small spine adjacent to the ultimate long spine was measured and recorded as the small spine length. All measurements were made with an ocular grid bearing a moveable hair pointer. Ratios obtained from these measurements were computed in the following manner: (Figure 1.): (1) spine No. 1 length to spine No. 2 length; (2) spine No. 2 length to spine No. 3 length; (3) spine No. 1 length to tibial width; (4) spine No. 2 length to tibial width; (5) spine No. 1 length to spine No. 3 length; (6) spine No. 3 length to spine No. 4 length; and (7) small spine length to most posterior long spine length. The ratios for both males and females were substantially identical as were those for large and small females of the same species. Six specimens for each sex were measured where material permitted.

The specimens were mounted on slides in PVA (polyvinyl alcohol) medium and orientated in such a manner that the outer face of the tibia was exposed. This orientation was necessary for accurate measurements.

A few specimens were noted in which the long spine count on one tibia was different (by one spine) from that of the other tibia. The low percentage

[1]A portion of a thesis presented in partial fulfilment of the doctor of philosophy degree at the University of Connecticut 1955.

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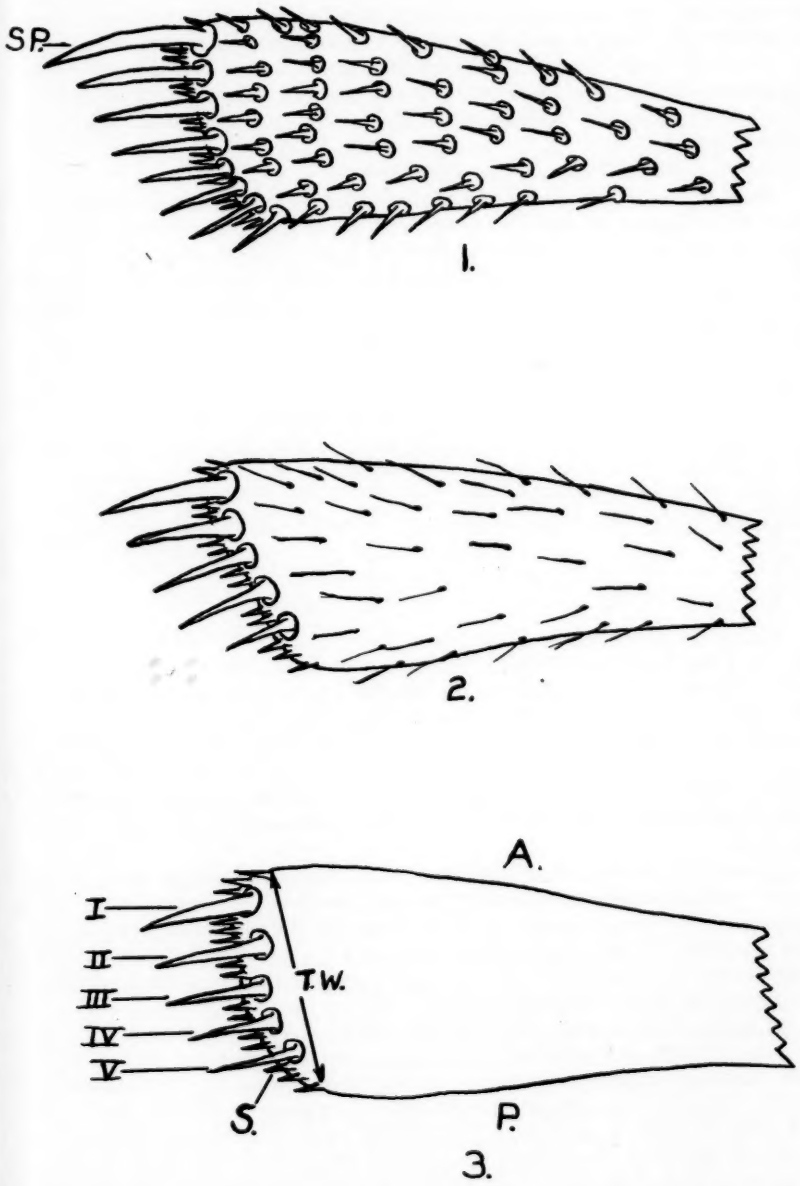

Figure 1. Tibial Comb Structures (Diagrammatic)—Outer Face. 1. Atrichopogon spp. showing heavy trichiation of tibia. SP—"spike" spine. 2. Culicoides spp. showing light trichiation and loss of "spike" spine. 3. Composite tibia showing terminology and method of measurements. A—anterior, P—posterior, I—first long spine, II—second long spine, III—third long spine, IV—fourth long spine, V—fifth long spine, S—measured small spine, T.W. measured tibial width.

of variability of the spine count does not preclude the usefulness of the character since only two specimens out of several hundred examined showed this condition. In the cases of different spine counts, the tibia with the lesser count was utilized.

Since the comb is present on both male and female tibiae and is identical in its pattern, specimens of either sex will run through the key with equal facility. This feature, common to both sexes, makes the character quite valuable as a taxonomic tool.

Generic Discussion

During the examination of specimens of the seven genera discussed in this paper, two features of the tibia were outstanding in their differences from one genus to another. The number of the long spines and the degree of trichiation of the tibia were noticeably different from genus to genus. The following table illustrates the tibial comb count as well as the associated tibial trichiation for the genera examined.

TABLE I

Genus	Comb Count	Tibial Trichiation
Atrichopogon	8–18 plus "spike"	long and heavy
Forcipomyia	7–9 plus "spike"	long and medium to heavy
Dasyhelea	6–7 no "spike"	medium length, sparse amount
Culicoides	4–7 " "	short length, sparse amount
Alluaudomyia	6–7 " "	short length, medium amount
Monohelea	5–7 " "	medium length, on distal ¼ only
Bezzia	5–6 " "	medium length, on tip of tibia

Heavy tibial trichiation as well as a large number of long spines together with an extra long "spike" spine appear to be the primitive situation in this dipteran family. This condition is exemplified by the genera *Atrichopogon* and *Forcipomyia*. Successive reduction of the long spine number, loss of the "spike" spine and reduction of the degree and amount of trichiation found on the tibia appears to be the fate of these structures from the more "primitive" genera to the more "advanced" genera. It is interesting to note that these tibial structures follow fairly closely the reduction of the hairiness of the wings, and the empodium.

Nielsen (1951) stated that members of the genus *Atrichopogon* in Scandinavia can be separated best on the basis of larval characters. An examination of the three species commonly occurring in Connecticut indicated that they are very easily separated through the use of the tibial comb. Likewise, an examination of several species of Connecticut *Forcipomyia* indicated that they can be separated with facility using the tibial comb.

At times there is some difficulty in placing a species definitely and easily into *Forcipomyia* or *Dasyhelea*, since some members of these genera are apt to be confused. Species belonging to the two genera, on the basis of the material examined, can be easily separated. *Forcipomyia* possesses the "spike" spine while *Dasyhelea* does not. This "spike" spine is extremely large in comparison to the other long spines and can be overlooked only if it is missing.

Future work with the tibial comb may aid taxonomists considerably in studies of lesser known genera, and in groups where large numbers of species occur.

The Genus Culicoides

Forty-two species of Neartic *Culicoides*, loaned through the courtesy of Dr. Willis Wirth of the U.S. National Museum were examined together with the

thirteen species of *Culicoides* found in Connecticut. These specimens showed four major patterns of the tibial comb: (1), one species with seven long spines; (2) four species with six long spines; (3), nine species with five long spines; and (4), twenty-eight species with four long spines.

The species with six and seven long spines do not show any trend towards subgrouping whereas the species with four and five long spines break down into subgroups based upon the position of the longest spine. The five spined species exhibit two patterns: (1), with the first spine longest, and (2), with the second spine longest. One species, *C. alaskensis* Wirth stands alone in this group in having the third spine longest.

The species with four long spines exhibit three subgroup patterns: (1), with spine one and two subequal, (2), with spine one longest, and (3, with spine two longest.

This genus has received much more attention from entomologists than any other genus in the family due principally to the medical importance of some and the annoying habits of most of the species. Recently Khalaf (1954) studied the species from a phylogenetic viewpoint, basing his deductions on the morphology of the male genitalia and the number and degree of sclerotization of the female spermathecae. He erected four subgenera on the basis of these characters. Root and Hoffman (1937), following a suggestion by Edwards (1926), divided the genus *Culicoides* into two series, A and B, based upon the spotting of the wings.

Table 2 lists the forty-two species examined, places them in the Series grouping of Root and Hoffman and the subgeneric grouping of Khalaf, and illustrates the tibial comb count.

An analysis of the tibial comb pattern lends some interesting light on these two groupings of the genus. Basically the six and seven spined species fall into Series A and the subgenus *Culicoides*, with the exception of *C. variipennis*. This species possesses six spines and falls into Series B and the subgenus *Monoculicoides*.

The five spined species place in Series B and the subgenus *Oecacta* with the exception of *C. venustus* and *C. obsoletus*, both of Series A and the subgenus *Culicoides*.

The four spined species place in Series B, seventeen species in the subgenus *Oecacta*, two species in *Monoculicoides* and five species in *Selfia*.

Root and Hoffman's Series A is assumed to contain the more primitive species and Series B to contain the more specialized species. All of the Series A species examined in this study possess six and seven spined tibiae with the exception noted above. All of the species placing in Series B possess four and five spines. It is apparent that the long spine count of the tibiae of the examined species follow the Series grouping fairly closely, by lumping the six and seven spines species and lumping the four and five spined species.

If Khalaf's assumption is correct that the ancestral form of the genus *Culicoides* possessed undivided parameres and a wing with the radial cell in a light spot, then the tibial comb involved a decrease in the number of spines as evolution progressed since Khalaf's most primitive species place in the subgenus *Culicoides* whose members possess six and seven spines. The most advanced species, according to Khalaf, belong to the subgenus *Monoculicoides*. Five species examined in this study place in this subgenus, namely *crepuscularis*, *canithorax*, *reevesi*, *alaskensis*, and *variipennis*. The first three species possess four spines with the first longest, the fourth species has five spines, and the

TABLE II
Comparison of the Groupings of the Genus *Culicoides*

Species	Root & Hoffman (1937) Series	Khalaf (1954) Subgenus	Tibial Comb Number of Spines
tristriatulus	A	*Culicoides*	7
yukonensis	A	*Culicoides*	6
inamollae	A	*Culicoides*	6
cockerelli	A	*Culicoides*	6
variipennis	B	*Monoculicoides*	6
alaskensis	B	*Monoculicoides*	5
venustus	A	*Culicoides*	5
stellifer	B	*Oecacta*	5
arboricola	B	*Oecacta*	5
monoensis	B	*Oecacta*	5
villosipennis	B	*Oecacta*	5
obsoletus	A	*Culicoides*	5
ousarani	B	—	5
guttipennis	B	*Oecacta*	5
salihi	B	*Oecacta*	4 (1 & 2 subeq.)
spinosus	B	*Oecacta*	4 (1 & 2 subeq.)
biguttatus	B	*Oecacta*	4 (1 & 2 subeq.)
brookmani	B	*Selfia*	4 (1 longest)
reevesi	B	*Monoculicoides*	4 (1 longest)
canithorax	B	*Monoculicoides*	4 (1 longest)
melleus	—	—	4 (1 longest)
nanus	B	*Oecacta*	4 (1 longest)
baueri	B	*Oecacta*	4 (1 longest)
haematopotus	B	*Oecacta*	4 (1 longest)
mohave	B	*Oecacta*	4 (1 longest)
furens	B	*Oecacta*	4 (1 longest)
crepuscularis	B	*Monoculicoides*	4 (1 longest)
floridensis	—	—	4 (1 longest)
tenuistylus	B	*Selfia*	4 (1 longest)
denningi	B	*Selfia*	4 (1 longest)
multipunctatus	B	*Selfia*	4 (1 longest)
weesi	B	*Oecacta*	4 (1 longest)
utahensis	B	*Oecacta*	4 (2 longest)
travesi	B	*Oecacta*	4 (2 longest)
copiosus	B	*Oecacta*	4 (2 longest)
hieroglyphicus	B	*Selfia*	4 (2 longest)
palmerae	B	*Oecacta*	4 (2 longest)
jamesi	B	*Selfia*	4 (2 longest)
unicolor	B	*Oecacta*	4 (2 longest)
piliferus	B	*Oecacta*	4 (2 longest)
paraensis	B	*Oecacta*	4 (2 longest)
usingeri	B	*Oecacta*	4 (2 longest)

fifth species has six spines. Assuming Khalaf to be correct in regard to species advancement and that the tibial comb evolved concurrently with the genitalia, then the ancestral form of the genus *Culicoides* probably possessed seven or more tibial comb spines and as evolution progressed the tibial comb underwent reduction and developed four and five spines. Additional evolution occurred in the four spined species with the relative lengths of the long spines progressively changing from subequality to either the first or second long spine becoming the longest.

One concrete feature of the tibial comb as an aid in identification is the facility with which similar species may be separated. For example two species, *spinosus* and *piliferus* are nearly indistinguishable except for male genitalia. However, through the use of the tibial comb, the females are readily separable. Two other species, *piliferus* and *unicolor*, regarded by Wirth (1952) as variations of the same species, show very small differences in the tibial comb pattern.

These differences may be due to slight variation in the comb or in poor orientation of the tibia during examination. Small series of *unicolor* were available. Another species where wide variation occurs throughout its range is *C. obsoletus*. An examination of many specimens from widely different areas indicated that the tibial comb was constant regardless of the variation exhibited by the thoracic markings or the wing spotting. The *guttipennis, arboricola, villosipennis, ousarani* complex of species are rather difficult to separate, except on the basis of the male genitalia, but can be easily separated by utilization of the tibial comb. All four species have five long spines but *arboricola* has the second spine longest, *villosipennis* the second and third subequal, and *ousarania* and *guttipennis* the first spine longest. The last two species are easily separated by the ratio of the small spine to the last long spine.

Key to the Neartic Species of *Culicoides* Based Primarily Upon the Tibial Comb

1.	With seven long spines	*tristriatulus* Hoff.
	With six or less long spines	2
2.	With six long spines	3
	With five or less long spines	6
3.	Spine No. 2 longest	4
	Spines No. 1 and No. 2 subequal	5
4.	Spine No. 3 shorter than tibial width	*yukonensis* Hoff.
	Spine No. 3 longer than tibial width	*inamollae* Fox & Hoff.
5.	Spine No. 3 much shorter than tibial width	*variipennis* (Coq.)
	Spine No. 3 and tibial width subequal	*cockerelli* (Coq.)
6.	With five spines	7
	With four spines	15
7.	Spine No. 3 longest	*alaskensis* Wirth
	Other than spine No. 3 longest	8
8.	Spine No. 2 longest	9
	Spine No. 2 not longest or spine No. 2 subequal with either spine No. 1 or No. 3	10
9.	Spine No. 1 and No. 3 subequal	*venustus* Hoff.
	Spine No. 1 longer than spine No. 3	*stellifer* (Coq.)
10.	Spine No. 1 and No. 2 subequal	*arboricola* R. & H.
	Spine No. 1 and No. 2 not subequal	11
11.	Spine No. 1 longest	12
	Spines No. 2 and No. 3 longest and subequal	*monoensis* Wirth
12.	Spine No. 2 and No. 3 subequal	*villosipennis* R. & H.
	Spine No. 2 longer than No. 3	13
13.	Cell R2 partially or wholly in a white spot	*obsoletus* (Meig.)
	Cell R2 in a dark spot	14
14.	Small spine more than half as long as spine No. 5	*ousarani* Khalaf
	Small spine less than half as long as spine No. 5	*guttipennis* (Coq.)
15.	Spine No. 1 and No. 2 subequal	16
	Either spine No. 1 or No. 2 longest	18
16.	Wings spotted	17
	Wings unspotted	*salibi* Khalaf
17.	Wing with more than two light spots	*spinosus* R. & H.
	Wing with but two light spots	*biguttatus* (Coq.)
18.	Spine No. 1 longest	19
	Spine No. 2 longest	33
19.	Spine No. 1 longer than tibial width	24
	Spine No. 1 shorter than tibial width or spine No. 1 and tibial widths subequal	20
20.	Spine No. 1 shorter than tibial width	21
	Spine No. 1 and tibial width subequal	23
21.	Spine No. 2 and No. 3 subequal	*brookmani* Wirth
	Spine No. 2 longer than No. 3	22
22.	Small spine more than half as long as spine No. 4	*reevesi* Wirth
	Small spine less than half as long as spine No. 4	*canithorax* Hoff.
23.	Yellow species	*melleus* (Coq.)
	Darker species	*nanus* R. & H.

24. Tibial width shorter than spine No. 2 ..... *baueri* Hoff.
Tibial width longer than spine No. 2 or tibial width and spine No. 2 subequal 25
25. Tibial width longer than spine No. 2 26
Tibial width and spine No. 2 subequal 27
26. Spine No. 3 longer than spine No. 4 ..... *haematopotus* Mall.
Spine No. 3 and No. 4 subequal ..... *mohave* Wirth
27. With spotted wings 28
With unspotted wings 29
28. Three light spots in cell R5 ..... *furens* (Poey)
Two light spots in cell R5 ..... *crepuscularis* Mall.
29. Light yellow in color ..... *floridensis* Beck
Darker in color 30
30. Small spine less than half as long as spine No. 4 ..... *tenuistylus* Wirth
Small spine half as long as spine No. 4 or longer 31
31. Spine No. 3 longer than No. 4 ..... *denningi* Wirth
Spine No. 3 and No. 4 subequal 32
32. Small spine half as long as spine No. 4 ..... *multipunctatus* Mall.
Small spine more than half as long as spine No. 4 ..... *weesi* Khalaf
33. Spine No. 2 shorter than tibial width ..... *utahensis* Fox
Spine No. 2 longer than tibial width or subequal with tibial width 34
34. Spine No. 2 longer than tibial width 35
Spine No. 2 and tibial width subequal 38
35. Spine No. 1 shorter than tibial width ..... *travesi* Varg.
Spine No. 1 and tibial width subequal 36
36. Small spine more than half as long as spine No. 4 ..... *copiosus* R. & H.
Small spine less than half as long as spine No. 4 37
37. Spine No. 3 and No. 4 subequal ..... *hieroglyphicus* Mall.
Spine No. 3 longer than spine No. 4 ..... *palmerae* James
38. Spine No. 1 and tibial width subequal 39
Spine No. 1 shorter than tibial width 40
39. Small spine more than half as long as spine No. 4 ..... *jamesi* Fox
Small spine half as long as spine No. 4 or shorter ..... *unicolor* (Coq.)
40. Spine No. 1 longer than spine No. 3 ..... *piliferus* R. & H.
Spine No. 1 and No. 3 subequal 41
41. Spine No. 3 and No. 4 subequal ..... *paraensis* (Goeld.)
Spine No. 3 longer than spine No. 4 ..... *usingeri* Wirth

Summary

A previously little used character, the tibial comb, has been examined in some detail to determine its possibility as an additional taxonomic aid in the study of the Ceratopogonidae. From the study it is apparent that the tibial comb can be used either by itself, or in conjunction with other taxonomically significant structures in the separation of species, and at times, in placing difficult specimens in the proper genus. A key has been constructed, primarily on the basis of the tibial comb, which permits separation of forty-two species of Neartic *Culicoides*. A short discussion is made of the various systems of breaking the genus *Culicoides* into subgroups together with the relation of the tibial comb to these groupings.

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The Present Status of Biological Control

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In a recent paper Taylor (1955) has discussed the status of biological control with particular reference to its present and future value as a method of control of insect pests. A number of his remarks are questionable, and his conclusions that present methods of biological control are of little value are not valid. His broad thesis is that insect pests with which the biological control method is effective have already been satisfactorily dealt with and that there no longer remain problems where spectacular results may be expected: moreover, that with the modern insecticides available, biological control has in many cases been rendered useless. It would be as well therefore to examine carefully his main contentions, and it should be pointed out at the outset that Taylor's criticisms of the methods of biological control, and of the claims made by entomologists working in this field, are vague, and although he does not actually say so he insinuates that biological control workers make or have made unjustified claims as to the success of a number of projects undertaken.

I do not think that the term biological control has in the minds of most entomologists been restricted, as is suggested by Taylor, to the action of parasitic and predatory insects on other insect pests, but rather to the control exerted on any animal or plant by biotic factors. Even such "classic" examples of biological control as the introduction of the mongoose and Surinam toad into the West Indies do not come into the former category. More recently the successful use of *Gonaxis*, a predaceous snail, against the giant snail, *Achatina fulica*, in Hawaii and Agiguan is another example of biological control where no insect is involved; the use of *Lebistes reticulatus* and *Gambusia* spp. against mosquitoes might also be cited. In addition use has been made in biological control work of fungi, (e.g. *Metarrhizium anisopliae* (Metch.), the green muscardine, and *Beauveria bassiana* (Bals.), the white muscardine), bacteria (e.g. *Bacillus popilliae* Dutky and *B. lentimobus* Dutky against the Japanese beetle), and viruses (e.g. against *Colias philodice eurytheme* Boisd., the Alfalfa butterfly, in California (Steinhaus and Thompson (1949)), and against *Gilpinia hercyniae* (Htg.), the European Saw-fly in Canada (Balch and Bird (1945)).

Taylor makes no mention whatever of the biological control of noxious weeds, in which field there have been some notable successes, including some comparatively recently (e.g. those of *Opuntia* spp. in Australia (see Dodd, (1929), (1940)) and South Africa (Pettey (1948)), *Hypericum* in Australia (see Wilson (1943), Wilson and Campbell (1943)) and in Northern California and Oregon (Holloway and Huffaker (1951)), *Cordia* in Mauritius (see Simmonds (1949) and Williams (1951)), *Clidemia* in Fiji (Simmonds (1934), Lever (1946))).

Taylor does not attempt to cite a large number of examples of successful or unsuccessful attempts at biological control. His argument is somewhat weakened by the fact that he cites 6 successful campaigns in the earlier part of the period under review (1905-30) while for the second period (1930-55) as the "few other similarly successful cases" he mentions the same number. This hardly indicates that biological control has been so much less successful latterly, even if the total number of projects undertaken in the later period has been greater.

All workers in the field of biological control would agree that the proportion of projects which have been successful has been small, and quite naturally in the earlier days those problems were tackled first which gave most promise of

speedy success with this method. However the experience of the past few years does not substantiate Taylor's claim that biological control successes "will become increasingly rare events". The control of *Cordia* in Mauritius (1948), that of *Aleurodicus cocois* Curt. in Barbados by *Prospaltella* sp. (1950, R. W. E. Tucker in litt.) and that of *Dacus ferrugineus dorsalis* Hend. in Hawaii (Carter, (1952)), might be cited as examples of this. Naturally it is impossible to state categorically that the control obtained in these instances will be permanent, but there seems every reason to believe so.

In spite of increasingly efficient quarantine services insect and plant pests still become established in new areas (e.g. *Dacus ferrugineus dorsalis* in Hawaii, *Anthonomus grandis* Boh. in Venezuela, *Carulaspis visci* (Schr.) and *Pulvinaria psidii* Mask. in Bermuda, *Aleurocanthus woglumi* Ashby in the Seychelles). With changing methods of cultivation and particularly with the formation of large areas of a single crop (or forest trees) in newly developed areas the importance of a number of insect pests has increased. Recently developed and improved varieties of some crops are found to be more susceptible to insect attack (e.g. new varieties of sugar cane more heavily attacked by *Diatraea* spp.). In addition many species of insects are now known to cause more serious damage than was formerly attributed to them, or may cause greater damage in a somewhat changed environment (e.g. as may be the case with *Pseudaulacaspis pentagona* (Targ.) in Bermuda now that the cedars have been virtually eliminated). Additional problems of insect and weed control are thus continually being created and some will undoubtedly continue to afford increased possibilities for biological control methods in the future. Whether or not biological control will be successful depends entirely on the species involved, their parasite and predator complexes, the areas invaded, and the efforts put into a biological control campaign. Until an investigation is made, and something is known of the ecology and natural enemies of the pest in its original habitat, no opinion as to the possibilities of biological control is valid. Moreover even when investigations of this nature have been made the only real test is to try the natural enemies in the new environment extensively and on an adequate scale. In fact each introduction of an agent of biological control into a new area is in the nature of an experiment the results of which cannot be accurately predicted.

Following the introduction of natural enemies of a pest into a new area the parasite or predator may or may not be able to establish itself in the new environment. Very often, even though conditions appear to be most favourable, no recoveries of the introduced species are made. Sometimes a species becomes established and then disappears inexplicably (e.g. temporary establishment of *Metagonistylum minense* Tns. against *Diatraea saccharalis* L. in Trinidad (Simmonds (1951)), or some explanation may be forthcoming (e.g. the failure of *Cryptolaemus montrouzieri* Muls. to become established permanently in Bermuda owing to predaceous lizards, *Anolis grahami* (Simmonds (1955))). Permanent establishment may occur but no worth while decrease in the attack by the pest may follow (e.g. *Agathis stigmaterus* (Cress.) in Florida against *Diatraea saccharalis*, *Dasyscapus parvipennis* Gah. in Trinidad against *Selenothrips rubrocinctus* Giard.). In these cases attempts at biological control have been obviously unsuccessful.

Taylor implies that to be successful biological control must reduce a pest to such a level that it no longer necessitates any further control measures of any kind. This is wrong. It is quite possible to have an economically worth while reduction in damage caused by a pest without rendering it economically negligible. As an example of this the introduction of *Lixophaga diatraeae* Tns., a larval para-

site of *Diatraea saccharalis*, into St. Kitts might be cited (Box (1933)). Prior to this introduction the percentage of joints of sugar-cane bored by *Diatraea* was about 20% entailing a loss of sugar of some 10%. After *Lixophaga* was established joint infestation was reduced to some 7% and sugar loss to about 3.5%. This reduction has continued for some 20 years. Now although there is still considerable damage to the cane, and it might be possible to reduce this further, it is obvious that biological control has been of considerable value. As further examples might be quoted the control of several species of scales on citrus in California (and Florida) where biological control may in some areas, which may vary from season to season, be sufficient to make any chemical control unnecessary (De Bach and Bartlett (1951), etc.). Careful investigation of parasitism is now recommended in some cases by workers in the field of chemical control before application of insecticides (e.g. Carmen, Elmer and Ewart (1954)). It does not seem to be a criterion of a successful biological control project that following it other measures are unnecessary, but as in these cases, it is certainly economically worth while that "a useful degree of control has been achieved". I do not think that this should give the impression that "the results are inadequate or temporary".

Although "the literature of this subject contains many statements to the effect that particular parasites have been introduced and successfully established" no entomologist would claim that this was anything more than a step in the right direction towards the objective: an economically worthwhile decrease in the damage caused by the pest in question; nor would it be suggested that a high percentage of parasitism necessarily brought about economic control. It is a well known fact that a high percentage mortality at one stage of an insect life history is often insufficient to reduce the damage caused. The suggestion that an "unbiased assessment" of the value of biological control is necessary implies that workers in this field, as opposed, for example, to those in the field of chemical control, are incompetent to estimate the degree of control effected as the result of the introduction of a beneficial species, or are dishonest. Taylor gives no specific references to these statements to which he objects, and there are only two references in the entire article, hence it is difficult to be specific in repudiating his criticisms, and the very fact of doing so may give the false impression that these criticisms are justified. It is certainly true that for a number of reasons the exact assessment of the result of the introduction of a natural enemy is very much more difficult than that of an application of insecticide (Clausen (1954)) but this does not alter the value of biological control.

I would very strongly disagree with the contention that supporters of biological control "in the narrow sense" (or in any sense) have been on the defensive against the supporters of chemical control, nor are we "reluctant to admit the limitations of the method". There are many problems where it seems likely that detailed investigations as to the possibilities of biological control are not alone likely to produce the desired results (e.g. *Scyphophorus acupunctatus* Gylh., the sisal weevil in East Africa, *Prepodes* spp., the citrus weevils of the Greater Antilles etc., *Melittomma insulare* Fairm. in the Seychelles, the cocoa beetle, *Steirostoma depressum* L., in Trinidad and Grenada). In such cases exponents of biological methods would frankly state that the possibility of obtaining successful control, even after extensive and costly investigation, would be remote, and they themselves would recommend that modern chemical control methods should be tried. There is, I think, a considerable agreement between investigators in both fields as to the limitations of both methods and as to the possible deleterious effects which may in some cases be caused through widespread use

of powerful insecticides; this in spite of the considerable commercial pressure brought to bear in favour of the use of insecticides, a pressure which the worker in biological control cannot or would not in all honesty be able to exert. Co-operation between biological control and chemical insecticide investigators is seen in the modern concepts of use of both methods against scales in citrus in California (see De Bach and Bartlett (1951), De Bach (1951), Clausen (1954), De Bach, Landi and White (1955)). Taylor mentions several dangers inherent in the continuous use of chemical insecticides—gradual development of resistant strains of the pest, build up of toxic residues in the soil, and the effects of the chemical on insects other than the pest it is desired to control, and on arthropods in general. The importance of these will obviously vary with different insect pests, under different conditions and with different insecticides, but in many cases may be very important.

As mentioned above the results of biological control projects vary from complete successes to complete failures, which from the very nature of the method of introducing living organisms into new environments, and the unpredictable nature of their reaction to these, form the majority of projects undertaken. Partial control resulting from introductions of natural enemies is not uncommon, and this may be "partial" in that it results in an economic though incomplete reduction in the damage caused by the pest, or "partial" in the sense that it is insufficient to produce adequate control continually, or that it does so only over part of the range of the pest. In such cases use of chemical methods of control may or may not be worth while economically, dependent on the value of the crop, the damage caused, cost of insecticide application, and the degree of control obtained by natural enemies. The introduction of natural enemies may reduce the area where chemical control is necessary, or diminish the number of applications of insecticide required to attain control. In a sense the two methods can certainly be complementary (see below), and a reduction of the area to be treated or the number of treatments necessary would be economically worth while.

The statement that "in general it (biological control) fails to compete with chemical methods, even those involving annual expense (and most chemical methods do) because it only succeeds in special circumstances which rarely occur" is very much oversimplified. In many instances where chemical methods are used biological control has never been attempted or considered, has been considered but given up very shortly as inapplicable or ineffective, or because the control attained is insufficient, (as for example with wrapping leaf tobacco where 100% protection from all pests is required). On the other hand in forest entomology chemical control is in general too expensive for extensive use, and we might well say that very often it "could not compete" with biological control methods. Rather, there are problems of insect control where an approach through biological methods seems indicated, others where it seems unlikely that such methods will be successful, and that chemical methods are more likely to solve the problem.

Taylor's statement that "Consideration of the successful cases (of biological control) leads to the conclusion that the method is more likely to succeed in islands than in continents, and in the tropics than in temperate climates" needs scrutiny. The distinction between "islands" and "continental areas" is far too general to have any bearing on the complexity or otherwise of the general ecology. The complexity of ecological conditions as they affect a given insect pest naturally affects the possibilities of biological control. Taylor claims that ecological conditions are simpler in a tropical island than in a continental area.

There is every gradation in the complexity of the ecology of tropical islands, from that of a newly formed volcanic island such as Krakatoa, through recent coral islands, such areas as Hawaii where the endemic flora and fauna cannot in general compete with exotic forms, to the West Indies and islands such as Trinidad which are ecologically very similar to the nearby mainland, and to large areas such as New Guinea and Madagascar. A possible distinction with regard to biological control seems to be rather between an area of fairly equable climate and one where drastic differences in climate occur between summer and winter or between wet and dry seasons. In these latter areas active insect life in the field may stop for a considerable period of the year, and heavy mortality may occur. This obviously has an effect on the course of the development of the population of both a natural enemy and its host, and may each year hinder the former by reducing to a minimum the population of the latter. However such an effect is not confined to areas with this type of climate, nor is this type of climate particularly characteristic of all tropical islands. In Trinidad, an island, the dry season prevents almost entirely the development of the populations of the sugar-cane frog-hopper (*Aenolamia varia* (Dist.)), and therefore each year reduces to a minimum the population of the nymphal predator *Salpinogaster nigra* Sch. On the other hand a "continental climate" may favour a parasite; for example in Western North America *Cryptus inornatus* Pratt is an ectoparasite of full-grown larvae of *Loxostege sticticalis* L. in their cocoons (Simmonds (1948)). In the autumn full-grown host larvae form cocoons in the soil in which they pass the winter. They are attacked by *Cryptus* in the autumn, and in the spring the progeny of these *Cryptus* begin to emerge from their cocoons earlier than the *Loxostege* larvae pupate, and are able to produce at least one more generation of parasites on these same groups of cocoons. This type of climate has thus provided a parasite with a double opportunity to parasitise the same group of hosts.

If continental areas are in general unfavourable on account of their complex ecology and climate for the building up of populations of parasitic and predaceous insects it seems odd that these same areas have proven very favourable for some introduced phytophagous species, e.g. European corn-borer and Gypsy moth in North America, *Hyphantria cunea* Dru. and *Leptinotarsa decemlineata* Say. in Europe. In certain insular areas (or ecological islands) where the endemic fauna *is* small or specialised introduced pests have little or no competition, and introduced natural enemies have similarly little or no hindrance to building up a large population at the expense of the host. In other island areas this does not hold. Taylor's claim that "parts of Australia, California and Kenya" "are isolated by natural barriers and are limited in flora and fauna" and therefore offer conditions where biological control might be expected to be more easily effected is unfounded. It is difficult to see what effective natural barriers to plant and animal dispersal occur in Kenya or California, and both these areas have a complex and not particularly specialised flora and fauna. Apart from the comparatively equable climate they are no different from other areas from the point of view of insect biology.

Of the twelve examples quoted by Taylor as outstanding successes of biological control four are from continental areas. It is rather begging the question to state that these have occurred in fact in "ecological islands" since the area where a given crop is grown, be it large or small, must obviously be in most cases of the nature of an "ecological island". It does seem justified to state that often successful biological control projects attain their end result more quickly in certain tropical islands than elsewhere, but this is due to the possibilities of

continued reproduction of the parasite or predator resulting in the building up in a limited area of a dense population. The severity of a temperate continental winter or of a severe dry season may check the increase of a parasite or predator, but it also influences the population of the host. As examples of biological control successes in continental areas might be cited that of the wheat stem saw-fly, *Cephus pygmaeus* L., by *Collyria calcitrator* Grav. and the control of the spruce saw-fly, *Gilpinia hercyniae*, Htg., by a virus disease, both in North America. The wheat-belt of Canada and the United States and the spruce forests of Northern Canada can hardly be termed "ecological islands" in the accepted sense of the term.

Unfortunately in many aspects of this controversy there is much speculation and too little fact or experimental work.

The criticism that "in most attempts at biological control parasitic or predatory insects, themselves little known ecologically, are introduced into conditions which are also inadequately known" is unfortunately quite justified, but this is not due to any fault of the entomologists but to the desire of the authorities financing the investigations to obtain quick results. Often much might be learned from a detailed investigation of the population variations following a successful introduction, or of the reasons for the failure of an introduction, but it is only in very few cases that such research has been made possible.

The selection for introduction of the most promising natural enemies of a given pest is difficult. It is well known that many species which can be bred with ease in large numbers in the laboratory are quite useless in the field, and may never become established. On the other hand species which are difficult to handle in the laboratory may become readily established in the field and breed rapidly. As an example of this, two introduced parasites of *Ascia rapae* (L.) in North America were sent to Barbados for trial against *A. monuste* (L.). In the laboratory *Pteromalus puparum* L. bred very rapidly on the pupae of this host, tens of thousands were liberated, and not a single recovery was made. *Apanteles glomeratus* L. could not be induced to attack *A. monuste* larvae in the laboratory but a few were liberated in the field, the species became quickly established and reduced the numbers of *Ascia* considerably. Subsequently the efficiency of the parasite was reduced by a hyperparasite, *Elasmus* sp. Here we have an example of a hyperparasite limiting the effectiveness of a parasite in a tropical island of comparatively recent formation with a limited fauna and flora.

In Taylor's article there seems to be very much more stress than is justified on the comparative ease of introductions into tropical islands as opposed to other areas. He does not show convincingly that the requirements necessary for a natural enemy to become established are less rigid under these conditions. Detailed study is as necessary in a problem of a tropical island pest as in any other.

Rather than make arbitrary distinctions between continental and insular areas, it should be stressed that each problem of control presents its own peculiarities and difficulties, based on the general ecology of the host and that of its natural enemies in the given area, and in all cases these should be carefully studied.

In view of the difficulty in determining the reaction of a parasite or predator to its normal (or possibly nearly related) host in a different environment, or how local parasites and predators will react to it, it is impossible to predict which, if any, member of a given parasite/predator complex will be successful in establishing itself in a new area, whether "insular" or "continental", and if established what degree of control it will exert on its host. It is preferable to give all primary parasites and predators encountered a chance of becoming established in the new area. To what extent this is possible depends largely on the funds

available for the particular project, and this in turn will probably depend on the severity of the pest and the *a priori* indications as to the possibilities of biological control.

Basically this holds for all biological control problems, whether they relate to introduced pests in island or continental areas, tropics or temperate zones, or indigenous insects which have reached pest status owing to an alteration in the original environment or introduction of a new crop. As much investigation as possible should be made of a parasite or predator in its native habitat prior to introduction into a new area, as in this way it is more likely that the introduction will be made under optimum conditions for establishment. But lack of these basic studies should not preclude the liberation of a possibly beneficent species the potentialities of which are therefore unknown (provided there is obviously no danger in such an introduction). As Taylor points out for two of the examples of successful biological control which he quotes, with the coconut Hispid in Fiji a parasite was carefully selected after considerable study, whereas in the case of the coconut moth in Fiji the controlling parasite was selected far more empirically.

I would quite agree with Taylor's remarks on the biological control of virus vectors, where it would appear that a host population sufficient to maintain a controlling parasite or predator complex would also be sufficient to cause considerable transmission of virus. The same applies to such pests as *Amblypelta cocophaga* China and *Theraptus* spp. which cause nutfall in coconuts, and an extremely efficient parasite complex would be required to produce an economically worth while decrease in the pest population, since a very small population is able to produce considerable damage.

The explanation for the conspicuous failure of biological control to prevent the virtual elimination of the Bermuda cedar (*Juniperus bermudiana* L.) from Bermuda may be correct, and the fact remains that in this case where apparently biological control was the most promising method of control none of the numerous parasite and predator species introduced checked the scale (*Carulaspis visci*) sufficiently to prevent the death of most of the trees. It should be remembered that in this instance no other successful method of control, chemical or otherwise, was devised. There was no question of biological control not being able to compete with chemical methods. It might also be noted here that the failure of biological control might possibly be attributed to the fact that the problem occurred in an isolated semi-tropical island, according to Taylor under conditions most favourable for successful biological control. The loss of the cedars was probably due to the extreme sensitivity of the Bermuda species of *Juniperus* to very small numbers of scales. This local species of *Juniperus* has probably survived unchanged in this environment due solely to its isolated insular position.

There has certainly been in recent years "a tendency to organize the moving of parasites and predators about the world on an ever increasing scale". That, in most cases, negative results have been obtained is unfortunate, but I do not agree that it is "unsound and therefore to be regretted". In Fiji, as Taylor claims, spectacular success was obtained in the control of the coconut scale by the introduction from the West Indies of the Coccinellid *Cryptognatha nodiceps* Mshl. Similar success was obtained in the Seychelles against this coconut scale with Coccinellids from East Africa (Vesey-Fitzgerald (1941)). It does not seem "unsound" to "move around" Coccinellids attacking scales on coconuts in the West Indies to other areas where the same or similar scales occur (e.g. from Trinidad to Barbados against *Aspidiotus destructor* Sign., to the Cayman Islands

and St. Vincent against the same pest, and most recently to Sao Tomé e Principe off the West Coast of Africa where initial establishment (1955) has been spectacular, and there appears to be every prospect of successful control of the scale). It seems the logical procedure after having a spectacular success to try the same parasites or predators of the same or closely related pests on the same host plant growing under ecologically similar conditions. Similarly *Plaesius javanus* Er. the predator of the banana borer, *Cosmopolites sordidus* Germ., was introduced some years ago into Fiji and thence to Jamaica, where it was claimed it produced a significant decrease in borer damage. In the past few years this predator has been successfully introduced into Trinidad and has been liberated in Grenada, St. Vincent, St. Lucia, Dominica, Martinique and in East and West Africa in small numbers.

Taylor states that "it must be admitted that it is never possible to predict with certainty the result of any particular introduction" and that in continental areas the introduction of natural enemies must be largely a matter of trial and error; but it follows from this that successes may be obtained even though not expected, and since Taylor agrees that the biological control method is the best of all when it works, then it is quite reasonable to use the existing facilities and organizations to carry on such experimental introductions on a very extensive scale, particularly since this can now be often done with great ease and rapidity. Even though economic results are not obtained in the majority of cases the value of the few successes will more than offset the total cost.

As a further concrete example of the "present tendency to organize the moving of parasites and predators about the world on an ever-increasing scale" which Taylor considers "unsound" and "to be regretted" might be cited the introduction in 1950 into Indonesia against *Plutella maculipennis* Curt. of *Angitia cerophaga* (Grav.) from New Zealand where it was originally introduced from Europe (and also Canada) some years ago. This parasite has become quickly established in Indonesia and has reduced considerably the population of *Plutella* (Vos (1953)).

In the example of *Cosmopolites* too, is shown the point that biological and chemical control methods are not incompatible. *Cosmopolites* was until a few years ago most difficult to control, and the only methods of keeping it in some check consisted of clean cultivation, immediate removal of all attacked plants, and trapping of adults. With the advent of the persistent modern insecticides this pest could, with care, be completely controlled by the use of aldrin, dieldrin, or gammexane. However, although in a few areas these insecticides are extensively used, in most, particularly in peasant cultivations, insecticidal treatment is not carried out, and especially where cultivation is poor or there are abandoned estates banana borer is abundant. Under these circumstances any reduction in *Cosmopolites* which might be obtained from the introduction of predators is of value. It should be pointed out that the exact value of *Plaesius javanus* in controlling banana borer in either Fiji or Jamaica has never been properly determined and it may be impossible to do so; claims as to its value have unfortunately, as Taylor points out is so often the case, been vague.

However in this case biological and chemical methods are not necessarily mutually exclusive, and it should be remembered that even in cases where chemical control methods are known to be effective it does not mean that these will in fact be applied. This is particularly so with peasant holdings in primitive or poorly developed areas, and here biological control could be of undoubted value, even in cases where it was not as effective as chemical control.

There are on the other hand a number of insect pests where chemical methods have to date been impractical. For example there are the sugar cane moth borers of both New World tropics (*Diatraea* spp.) and the Old World (*Proceras* spp. etc.), and with the former at least considerable success has been attained with biological control.

Taylor's reference to the "field of ecological control" is rather vague. He defines it as "control based on thorough knowledge of the ecology and population dynamics of the insects to be controlled", but such information should be the background for all methods of control. If by ecological control Taylor means a combination of the modifications of cultural practices which minimize attack by the pest and encourage subsequent mortality, including that caused by natural enemies, then biological control forms an integral part of ecological control (see Clausen (1951)). As examples Taylor refers to the control of the Alfalfa butterfly in California by a virus (Steinhaus and Thompson loc. cit.) and to that of the Japanese beetle by a "virus", by which Taylor presumably means the two bacteria *B. popillae* and *B. lentimobus* (Dutky (1940), White and Dutky (1940)). Both these are perfectly good examples of biological control, and as Taylor says "are an encouraging example of what can be achieved by patient, fundamental research over a long period". Moreover in these two examples the research involved was a study of the effects of viruses and bacteria as biological control agents, not a study in ecology.

Taylor refers, too, to the "intensive studies" which have followed the "outbreaks of mites and Coccids that have resulted from the general use of modern insecticides on fruit trees". These studies have certainly been of an ecological nature but have clearly indicated the most important part played by biological control in keeping in check numbers of mites and Coccids, and that it was the detrimental effect of insecticides on the natural enemies that determined the rise of the Coccids and mites to pest status. Further examples of this may be found in the works on Californian citrus scales already referred to.

Taylor's plea for more fundamental work on the ecology of insect pests would be endorsed by every worker in the field of biological control. With some biological control projects this type of investigation has been carried out as far as is possible, but in most cases funds are limited, speedy results are required, and hence ecological investigation of a pest and its natural enemies in several types of environment have to be skimped. The greater the detailed information available concerning the pest and its natural enemies the greater the chance of obtaining successful biological control, if in fact suitable natural enemies are available.

That natural enemies constitute only one group of factors affecting insect abundance is obvious; nor need they be the most important for the effect of their presence or absence to be economic control of a pest or its continual increase and spread. The effect on a pest of a comparatively small additional mortality factor over a number of generations may be considerable (e.g. the present status of *Diatraea saccharalis* in British Guiana after many years parasitism by *Metagonistylum minense* (Bates 1955)).

It would seem therefore that Taylor's claims that the present and future value of the biological control method is very limited are unfounded. There is no question of biological control failing to compete with chemical methods; some problems may be solved more readily by one method, some by the other. Nor are the two methods mutually exclusive, as Taylor states, but the one can be complementary to the other.

Even in cases where very effective chemical methods of controlling a pest are known they may be uneconomic in certain regions. Very often, particularly with peasant crops in backward areas, these methods though known are not applied. In such cases, even though all would agree that chemical methods would be more effective if they could be applied, biological control may remain the one practical method of reducing insect damage.

The dangers inherent in continuous use of powerful persistent insecticides have been mentioned, and these have been the subject of a considerable amount of research in recent years, with the result that even with a number of pests where chemical control methods are effective and practical increasing attention is being given to the possibilities of biological control.

That more fundamental work on the ecology of insect pests is desirable is beyond question, and it would seem that Taylor's plea for increased attention to "ecological control" in fact indicates the necessity for increased research into the possibilities of biological control, as natural enemies usually form an important part of the ecological factors influencing the abundance of an insect pest.

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Book Review

FISHING WITH NATURAL INSECTS. By Alvah Peterson, Entomology Division, Ohio State University, Columbus 10, Ohio, 176 pp., 65 plates, table of contents and general index. Price $6.00, distribution by the author.

This work by a well known entomologist is designed as a popular publication for fishermen. After some introductory remarks and a section on features that are important in the selection and use of insects for bait the author gives the essential facts about insect structure, development and classification and then describes the methods that may be used in collecting, trapping, transporting and maintaining insects for bait use and for killing and preserving them for the same purpose indicating also how a number of species may be reared. He then takes up the various groups of insects which are or may be taken by fish and in many cases gives precise information as to how they should be attached to the hook. He also discusses the use of artificial lures made to resemble insects and other animals. The work concludes with a section on the location and food of some common fresh water fishes.

There is no doubt that fishermen who are not entomologists will find in Professor Peterson's work a mass of information which has not hitherto been available to them and which will help them to get better results on the lakes and streams. As the author points out, the fishermen who use bait rely at present very largely on worms, crayfish or minnows. He is of the opinion that many common insects are more attractive to fish than worms, one reason being so far as known earthworms or their near relatives rarely if ever occur in streams, ponds or lakes and consequently are never common food for fishes. While the information Professor Peterson gives about insects will certainly be quite familiar to his entomological readers who are fishermen yet this work may be very useful to them since it may induce them to experiment with easily available bait they have never thought of using.

Professor Peterson's work seems to be based mainly on his knowledge of the habits of fishermen in North America. In his section on blowflies he says that few fishermen, so far as known, have used large maggots for bait though they should be satisfactory for pan fish, bass and others. In Great Britain and no doubt on the continent also blowfly maggots are very extensively used particularly in stream or lake fishing. In the towns on the Thames River for example all fishing tackle shops carry large supplies of maggots which can be purchased by the cupful. They are treated in such a way that they have little or no odour

and they may be had dyed in various colours probably by mixing the colouring matter with the food. Not far from where I lived in England there was a gentleman who made part of his living by rearing maggots for fishermen and who called himself the "Maggot King of Buckinghamshire". This man published an article on his work in one of the fishing magazines. In this he noted that after long continued work in the rearing rooms the odour of the maggots and their food permeated his skin so that he became objectionable to the friends he met in the local public house even although he had taken a bath and changed his clothes. He said also that after he had bred a lot of blowflies continuously throughout the season starting from material collected in the field the oviposition rate fell off so that he was obliged to get new stocks at the beginning of every breeding season. This difficulty has often been encountered in the mass rearing of parasites.

English fishermen have also paid a good deal of attention to the method of fishing with natural insects and in a book called "The Fisherman's Vade-mecum" published in 1938 by D. W. Maunsell there is some very valuable information as to the exact methods that should be used in fishing for trout with natural insects. When Professor Peterson's book reaches a new edition this might be incorporated with advantage because live insects are in general rather difficult to handle in practice.

At any rate Professor Peterson is certainly to be congratulated on an interesting and original work which all fishermen whether they are entomologists or not can certainly profit.

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THE RUNGE PRESS LIMITED, OTTAWA
Mailed: Tuesday, October 30, 1956